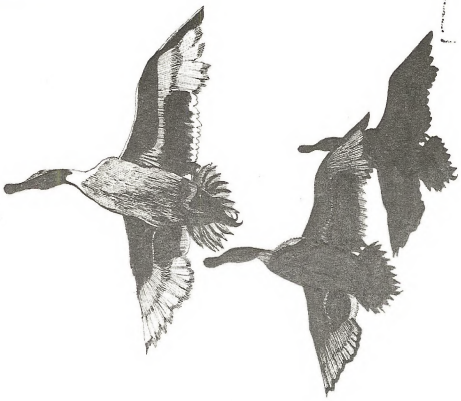

WETLANDS ECOLOGY FOR THE WESTERN UNITED STATES

An Abstracted Bibliography of Pertinent Studies

by

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United States Department of the Interior
Bureau of Land Management

Technical note 251

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ACKNOWLEDGEMENTS

May I express my thanks to the people who have helped me in this study: to Gary Meneghin who assisted in the preliminary literature search; to Howard Leach and Rolf Mall, of the California Department of Fish and Game, who gave me access to their wetlands files; to the librarians of the California Natural Resources Library, and the libraries of the University of California in Berkeley and Davis, who cooperated in the literature search.

Philip H. Arend

SECTION A

GENERAL REFERENCES, STANDARD TEXTS, KEYS

Fifty-nine titles are listed.

Allee, W. C., A. E. Emerson, O. Park, T. Park, and K. P. Schmidt. 1949. Principles of animal ecology. W. B. Saunders Co., Phila., 837 pp.

A monumental twenty-year-old classic, still the outstanding work in this field. Section II (Chapters 11 through 17) contains basic information essential to an understanding of wetlands ecology.

Amos, W. H. 1967. The life of the pond. McGraw-Hill Publ., 232 pp.

A conservationist's picture primer, well illustrated and diagramed--a solid work despite its elementary nature. This is one of "Our Living World of Nature" series published in conjunction with the World Book Encyclopedia and produced with the cooperation of the U. S. Department of Interior.

Beetle, A. A. 1943. A key to North American species of the genus Scirpus based on the achene characteristics. Am. Midl. Nat. 29(2):533-538.

A key to 45 North American species of bulrush is offered, plus species distribution list and two plates.

Benton, A. H. and W. E. Werner, Jr. 1958. Principles of field biology and ecology. McGraw-Hill Book Co., Inc., 341 pp.

A compact, clearly written text. Contains less jargon and more usable information than most of the more pretentious ecological texts, since the book is directed to the field student. Students of wetlands will find Chapter Six, "Aquatic Plant Succession," succinct and clear. A useful annotated bibliography is appended.

Biester, H. E. and L. H. Schwartz, Ed. 1965. 5th Edition. Diseases of poultry. Iowa State Univ. Press, 1154 pp.

First Edition (1943) was edited by H. E. Biester and L. Devries. A standard text for veterinarians, this book contains basic medical and diagnostic information on waterfowl and upland game bird diseases: botulism, fowl cholera, aspergillosis, sarcocystis, etc.

Broley, J. 1950. Identifying nests of the Anatidae of the Canadian prairies. J. Wildl. Mgt. 14(4):452-456.

This standard and useful reference presents a key, with photos, to the nest down of Anatidae.

Brown, D. L. 1954. Methods of measuring vegetation. Commonwealth Agr. Bur., Bucks, England.

The generally accepted text.

Calhoun, A. (Ed.) 1966. Inland fisheries management. Res. Agency, Calif. Dept. Fish and Game, 546 pp.

A compendium of information, clearly written and directed to the field level. Seventy-six chapters of reference; covers 47 common species of game and rough fish, plus information on population dynamics, management research, etc.

Chapman, V. J. 1960. Salt marshes and salt deserts of the world. London, L. Hill Ltd.; Interscience Publishers, Inc., N. Y., xvi and 392 pp.

The definitive work in the field. A scholarly work, covering 25 years of study on coastal and inland salt marshes, has as its purpose to present a general picture of salt marshes and related tracts, and to give some account of the physiology and autecology of the species that comprise this amphibious and peculiar vegetation.

Donahue, R. L., E. F. Evans, and L. I. Jones. 1956. The range and pasture book. Prentice-Hall Publ., Englewood Cliffs, N. J., 406 pp.

Plants resistant to salt injury: bermuda grass, rhodesgrass, and rescuegrass. Plants moderately salt-tolerant: sweetclovers, perennial ryegrass, birdsfoot trefoil, strawberry clover, dallisgrass, sudangrass, alfalfa, reedfescue, orchardgrass, big trefoil, tall oatgrass. Irrigation water requirements: ladino clover, 44 A/inch; alfalfa, 36 A/inch; sudangrass, 17 A/inch.

Fassett, N. C. 1940. A manual of aquatic plants. (Rev. app. E. C. Ogden, 1956). Univ. Wis. Press, 405 pp.

A standard classic for midwestern and eastern United States, now includes revisions and appendix on wildlife plant use. Keyed and illustrated, with taxonomy updated.

Fernald, M. L. 1950. "Gray's manual of botany." 8th Ed. American Book Co., N. Y.

A classic American technical botany, revised and updated. Emphasis is on plants east of the Continental Divide.

Fernald, M. L. and A. L. Kinsey. 1943. Edible wild plants of eastern North America. Idlewild, Cornwall on Hudson, N. Y., 452 pp. Rev. Ed. 1958. Harper, N. Y.

Many of the edible plants listed are ubiquitous wetland species; a knowledge of these will help the wetlands manager find useful by-products or perhaps a means to arouse a public interest in his marsh.

Hall, L. C. 1968. Bibliography of freshwater wetlands ecology and management. Wis. Dept. Nat. Res., Res. Rept. 33.

This computer-derived bibliography lists 3,302 numbered citations, categorized as follows: Plants and Plant Communities; Animals and Animal Communities; Soils, Ground Water, and Surface Water; Management and Artificial Wetlands; Values, Conservation and Destruction; Classification, Inventory and Survey; General and Miscellaneous. A 51-page supplement lists key words in the citation titles cross-indexed to the citation number. (N. B. The volume of wetlands literature is indicated by the fact that the Wisconsin bibliography with over 3,000 titles and this BIM bibliography with over 500 abstracted citations duplicate in only about 200 references. P.H.A.)

Hitchcock, A. S. 1950. Rev. Manual of the grasses of the United States. U. S. Dept. Agr. Misc. Pub. No. 200, Ed. 2, revised by A. Chase, 1051 pp.

The introduction includes uses, distribution, morphology, classification, and nomenclature of the grasses, followed by a description of subfamilies of the Gramineae and keys to the tribes. Excellent illustrations, as well as a small geographic distribution map, are presented with each species listed. This is an old and familiar standard reference.

Hochbaum, H. A. 1955. Travels and traditions of waterfowl. Minn. Press, Minneapolis, 301 pp.

This work relates the physiological and behavioral elements of waterfowl to the local flights and travels and to the annually cyclic migrations. It explores the traditional movement patterns and the changes in these patterns that now occur. Specifics of wetlands ecology are touched upon only incidentally.

Hotchkiss, N. 1964. Pondweeds and pondweedlike plants of eastern North America. USF&WS Circ. No. 187, 30 pp.

First pamphlet of a series, on field identification of marsh and water plants of this region, describes 27 pondweeds and 13 non-pondweeds. These aquatics are either floating-leaved or with all the leaves underwater. Underwater-leaved plants have either (a) oval, oblong, or lanceolate leaves or (b) thread- or ribbon-like leaves. This circular, clearly and simply written, has no key but excellent line drawings. Many of these ubiquitous water plants occur in western states.

Hotchkiss, N. 1965. Bulrushes and bulrushlike plants of eastern North America. USF&WS Circ. 221, 19 pp.

Second in series (Hotchkiss, 1964), this pamphlet describes 19 bulrushes and 4 bulrushlike plants, grouped in five categories. Author uses clear line drawings, rather than a key, for identification. This circular will be a useful tool for the field man who may lack technical background in botany.

Hotchkiss, N. and H. L. Dozier. 1949. Taxonomy and distribution of North American cattails. Am. Midl. Nat. 41(1): 237-254.

Four species of Typha are recognized and discussed: T. latifolia, T. angustifolia, T. domingensis, and T. glauca. A taxonomic history for each is given, species morphology is described and illustrated, and the distribution of each species is mapped. The paper contains no information on ecological tolerances of the plants.

Hotchkiss, N., F. M. Uhler, and W. S. Bourn. 1953. Classification of wetlands of the United States. USF&WS Spec. Sci. Report. Wildl. No. 20.

The twenty types of wetlands described are listed under the following regional categories: Inland Fresh, Inland Saline, Coastal Fresh, and Coastal Saline. The soil, geographic location, and vegetation of each type of wetland are also briefly outlined.

Johnsgard, P. A. 1965. Handbook of waterfowl behavior. Cornell U. Press, Ithaca, N. Y., 378 pp.

An important reference work for the specialist studying waterfowl behavior.

Johnsgard, P. A. 1968. Waterfowl; their biology and natural history. Lincoln, Nebr., 375 pp., 150 photos incl. 59 col. pls.

An up-to-date reference, written for the layman as well as the biologist, discusses distribution, ecology, migration, food, behavior, plumages, etc.

Klots, E. B. 1966. The new field book of fresh-water life. G. P. Putnam's Sons, N. Y., 398 pp.

This new Putnam Nature Field Book will replace, to a large degree, the 35-year-old "Field Book of Ponds and Streams" by Ann Haven Morgan that has long been a field companion to many wetland ecologists. Aquatic plants and animals, from bryophytes to alligators, are discussed and keyed out.

Kortright, F. H. 1943. The ducks, geese, and swans of North America. Am. Wildl. Inst., 476 pp.

Still the best single-volume treatment of waterfowl, although taxonomy is outdated or in disagreement and life histories (based on Bent) are outmoded. Fine illustrations.

Leopold, L. B. and W. B. Langbein. 1960. A primer on water. U. S. Dept. Int. Geol. Surv. Publ., U. S. Govt. Prtg. Ofc., iv and 50 pp.

Part 1, "Hydrology," in non-technical language presents elementary information of the science that concerns the relation of water to our earth; Part 2, "Water Use and Development," deals with water supply and uses and the basic grammar of city water systems, irrigation farm ponds, flood control, and waterpower. A brief glossary is appended.

Lincoln, F. C. 1950. Migration of birds. USF&WS Circ. 16, 102 pp.

Despite the age of this pamphlet, and despite a number of recently published books based on further research, Circular 16 has retained its popularity and is still widely quoted. To the practitioners of wetland ecology, the general information on bird migration and the specific data on species movements, routes, and travel dates found in this inexpensive and readily obtained pamphlet will be useful.

Martin, A. C. 1951. Identifying pondweed seeds eaten by ducks. J. Wildl. Mgt. 15(3):253-258.

Pondweed (Potamogeton) seeds are valuable duck food in the United States. Seeds of twenty-one species of pondweed are illustrated and briefly described.

Martin, A. C. 1954. Identifying Polygonum seeds. J. Wildl. Mgt. 18(4):514-520.

An illustrated key to the seeds of smartweeds (Polygonum spp.), important waterfowl food and cover plants.

Martin, A. C. and F. M. Uhler. 1939. Food of game ducks in the United States and Canada. USDA Bur. Biol. Survey Tech. Bull. 634, 157 pp., 153 pls.

A thirty-year-old standard classic reference work, extensively quoted and widely used. Although this work is now badly outdated, no other reference of such comprehensive coverage currently exists.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American wildlife and plants--a guide to wildlife food habits. McGraw-Hill. 1951. (Dover Press Edition 1961, paperback, $3.00).

Chapters five, six, and sixteen provide particularly useful references for students of wetlands ecology.

Mason, H. L. 1957. A flora of the marshes of California. Univ. Calif. Press, viii and 878 pp.

A unique reference work, of wider scope than the title implies. Applicable to most of the western states and designed to be used by non-botanists as well as plant specialists.

Matsumura, Y. and H. D. Harrington. 1955. The true aquatic vascular plants of Colorado. Colo. Agr. & Mech. Coll. Tech. Bull. 57, 130 pp., illus.

This brief regional botany contains 51 pages of cleanly drawn black-and-white illustrations accompanied by simple key, species description, and glossary of terms. Paperback. No price stated.

McAtee, W. L. 1939. Wildfowl food plants. Coll. Press, Inc., Ames, Iowa, 141 pp.

This out-of-print classic discusses productivity, food value, and use of aquatics by waterfowl. Principal chapter covers food plants by families, notes recognition, ecology, and use by wildfowl. Other chapters are concerned with environmental factors of aquatic plant growth. The book gives practical management suggestions such as pond construction, marsh blasting, and weed control. Unique and valuable to the field marsh manager is the glossary of vernacular names of food plants.

Morton, J. F. 1963. Principal wild food plants of the United States. Econ. Bot. 17(4):319-330.

Over a thousand wild plants that either have been or are still being eaten by humans in North America are listed: ferns, flowering plants, cacti (listed separately), lichens, fungi, and algae. Many familiar wetland plants are included.

Muenscher, W. C. 1944. Aquatic plants of the United States. Comstock Publ. Assoc., Inc., Ithaca, N. Y., 374 pp.

This standard aquatic plant reference contains simple keys as well as distribution maps and excellent illustrations. Taxonomy is now somewhat outdated.

Needham, J. G. 1916. The life of inland waters. Comstock Publ. Co., Ithaca, N. Y., 438 pp.

Subtitled "An elementary text book of fresh-water biology for American students" this book, long out of print but still available in many libraries, remains one of the best, easily read sources for the field man who often needs to know only what those wiggly things are in that bunch of waterweed and gunk from the bottom of the pond.

Niering, W. A. 1966. The life of the marsh; the North American wetlands. McGraw-Hill, N. Y., 282 pp.

An elementary treatment of marsh ecology is handsomely illustrated and just misses being a very good book. One of "Our Living World of Nature" series, published jointly with the World Book Encyclopedia and produced in cooperation with the U. S. Department of the Interior. A companion work to Amos, 1967.

Oliver, J. A. 1955. The natural history of North American amphibians and reptiles. D. Van Nostrand Co., Inc., ix and 359 pp.

Written in a semi-popular style, this is an authoritative account on basic biology, folklore, economic values, environmental relations, and food habits.

Otto, N. E. and T. R. Bartley. 1965. Aquatic pests on irrigation systems--identification guide. Water Res. Tech. Publ. No. 841, Bur. Recl., U. S. Govt. Prtg. Ofc., 72 pp. (Hardcover, $1.25).

A useful little handbook with succinct descriptions and full-color plates of 31 common freshwater aquatic plants and 4 invertebrates.

Pacific Southwest Inter-Agency Committee. 1958. A guide to the density survey of bottomland and stream-bank vegetation--by Subcommittee on Phreatophytes, Pac. S.W. Inter-Agency Comm. June 1958 (Provisional). 28 pp., 15 figs.

In the West, and particularly the arid Southwest, phreatophyte control is a highly controversial wildlife issue. This publication clearly defines terms, briefly describes and pictures the following common phreatophytes: saltcedar, cottonwood, willows, seepwillow, mesquite, arrowweed, greasewood, alder, saltgrass; and outlines three types of vegetation survey: reconnaissance, semi-detailed, and detailed. Techniques of a detailed survey are given.

Pennak, R. W. 1953. Fresh-water invertebrates of the United States. Ronald Press, N. Y., 769 pp.

A classical work, designed for the college senior or graduate level, contains valuable ecological notes on many species. The keys are relatively simple and most of the forms are illustrated with clear line drawings.

Phillips Petroleum Co. 1963. Pasture and range plants. Phillips Petroleum Co., Bartlesville, Okla. x and 176 pp.

Originally issued as separate pasture and range plant booklets, these publications have been brought together under one cover to create a most useful, as well as a superlatively illustrated, manual for the farmer or stockman. The plants, each described and pictured in full color, are grasses, legumes, forbs, woody plants and miscellaneous, and poisonous plants.

Reid, G. K. 1961. Ecology of inland waters and estuaries. Reinhold Publ. Corp., 375 pp.

Although a textbook primarily concerned with limnology, marshlands are considered and the chapters (13 and 14) on chemical-physical relationships in aquatic environments are valuable to the marsh ecologist. Extensive bibliography contains nearly 400 titles.

Scott, P. 1949, rev. 1961 and 1965. Key to the wildfowl of the world. Severn Wildfowl Trust, Slimbridge, Gloucestershire, England, 91 pp.

This small field book has become a standard waterfowl reference and identification text for U. S. wildlife schools. (Paperback copy in England $1.50, in U. S. $2.95.) Contains 23 full-color plates and several black-and-white illustrations of ducks, geese, and swans. The taxonomy was revised in 1965 and is currently accepted by most authorities.

Shaw, S. P. and C. G. Fredine. 1956. Wetlands of the United States; their extent and their value to waterfowl and other wildlife. USF&WS Circ. 39, iv and 67 pp., 12 figs., 21 pls.

A basic document for the marsh manager. Lists 20 wetlands types; generally classifies wetlands soils (peats and muck, alluvial); defines and discusses wetlands, the wetlands inventory and its use; provides a glossary of marsh plant names and a short list of references.

Steward, A. N., J. D. LaRea, and H. M. Gilkey. 1960. Aquatic plants of the Pacific Northwest, with vegetative keys. Oregon State Coll., Studies in Botany No. 11, 184 pp.

Mosses, liverworts, ferns, and flowering plants, with about 200 drawings.

U. S. Bureau of Reclamation. 1953. Water measurement manual. U. S. Dept. Int., Bur. Rec. Manual, Specialist Supplement, 271 pp.

A technical manual with tables, charts, formulas, illustrations, and descriptions useful in the measurement of irrigation water under the conditions which might be encountered in the irrigated western United States.

U. S. Bureau of Reclamation. 1960. Earth manual. U. S. Dept. Int., Bur. Rec., 751 pp.

A guide to the use of soils as foundations and as construction materials for hydraulic structures. Chapter headings: Properties of Soils, Investigation, Control of Earth Construction.

USDA. 1948. Yearbook of agriculture "Grass." U. S. Govt. Print. Ofc., 892 pp.

Useful reference.

USDA. 1955. Yearbook of Agriculture "Water." U. S. Govt. Print. Ofc. 751 pp.

Recommended for study:

"More wildlife from our marshes and wetlands" by P. F. Allan and W. L. Anderson, p. 589-596. Discusses marsh management in eastern and coastal states.

"Waterfowl and the potholes of the north central states" by T. A. Schrader, p. 596-604. Focuses on the drainage controversy in this region.

"Wetlands and the management of waterfowl" by S. P. Shaw and W. F. Crissey, p. 604-614. Presents the broad survey of the nation's wetlands and waterfowl of the mid-1950's.

USDA. 1957. Yearbook of agriculture "Soil." U. S. Govt. Print. Ofc., 784 pp.

Useful reference to general soil chemistry. Pays no heed to wildlife and direct information on wetland soils is scarce, save for one brief chapter on rice management (p. 658-663).

USDA. 1960. Yearbook of agriculture "Power to Produce." U. S. Govt. Print. Ofc., 480 pp.

Useful reference on agricultural machinery and powered equipment.

USDA. 1961. Yearbook of agriculture "Seeds." U. S. Govt. Print. Ofc., 591 pp.

Occasionally useful reference.

USDI. 1964. Waterfowl tomorrow. (J. P. Linduska, Ed.) USF&WS, U. S. Govt. Print. Ofc., 770 pp.

For a popularly-written federal publication, this is a surprisingly able compendium of solid information on North American waterfowl and their management. For wetlands study, note particularly the sections "Men at Work" and "A Helping Hand," but the entire text is a valuable reference work for the waterfowl specialist and the wetlands manager.

Ward, H. B. and G. C. Whipple. 1918. Fresh-water biology. John Wiley & Sons, Inc., ix and 1111 pp.

This outstanding classic First Edition was reprinted several times; was extensively revised in 1959 by W. T. Edmondson and published as a "Second Edition, Fresh-water Biology."

Weaver, J. E. 1965. Native vegetation of Nebraska. Univ. Nebr. Press, Lincoln, Nebr., 185 pp.

This small book by a noted American botanist contains information of special value to wetlands students working in the Plains States. The following chapters are particularly useful for plant zonation and succession study: Flood-Plain Forests; Lakes, Marshes, and other Wetland; Grasses of Bluestem Lowlands; and Forbs of Lowlands.

Welty, J. C. 1962. The life of the bird. W. B. Saunders Co., Phila., 546 pp.

An outstanding work; perhaps the best single-volume (and certainly one of the most readable) reference works on bird biology.

Wildlife Society. 1960. (H. S. Mosby, Ed.) Manual of game investigational techniques. The Wildl. Soc., xxii and 20 sections.

The standard professional manual for North American wildlife technicians. A new, revised (and, hopefully, more lively) edition will be issued in 1969.

Wright, A. H. and A. A. Wright. 1949. Handbook of frogs and toads of the United States and Canada. (3rd Ed.) Comstock Publ. Co., Inc., xii and 640 pp.

A standard reference. Work on the biology and taxonomy of the Amphibia, written with sparkle and wit--particularly in the "Journal Notes" and "Authorities' Corner."

SECTION B

WETLANDS MANAGEMENT PRINCIPLES

In Section B, 143 citations, each reference is selected to illustrate a basic principle of wetlands ecology or management.

Adams, D. A. 1963. Factors influencing vascular plant zonation in North Carolina salt marshes. Ecology 44(3):445-456.

Tide-elevation influences are the primary factors controlling distribution of salt marsh species. The mean elevation of occurrence above MSL (mean sea level) divided by ½ of the mean tide range of the area is a characteristic constant for each of the various salt-marsh species. Most salt-marsh species exhibit reduced growth and fertility with increased salinity. Salt concentrations equivalent to about 7% NaCl prevent establishment and survival of all species.

Addy, C. E. and L. G. MacNamara. 1948. Waterfowl management on small areas. Wildl. Mgt. Inst., 84 pp.

Tells sportsmen how to restore and improve habitat for waterfowl by controlled water levels, planting, weed control, etc. Detailed descriptions and pictures of construction methods of ponds and lakes are given.

Allan, P. F. 1956. A system for evaluating coastal marshes as duck wintering range. J. Wildl. Mgt. 20(3):247-252.

Describes a system of evaluating marshland by a method similar to that used by U. S. Soil Conservation Service in rangeland. Using the successional relationship of plants, marshes are classed according to how closely they approach climax stages. Plants are categorized in three groups based on their food value established from food habits studies. Percentage of these categorized plants in the habitat establishes a number value for the marsh. The technique is intriguing, but many valid criticisms are possible: food value is the only criterion used; for many areas food habits studies are scant or biased; the possibility of phenological change in food values of a marsh is not considered.

Alvord, W. and J. C. Peters. 1963. Channel changes in 13 Montana streams. Fisheries Div. Montana F. & G. Comm., 22 pp.

During 1962, thirteen Montana trout streams were surveyed to measure the amount of stream channel alterations. One-third of the total length of the streams surveyed (250 out of 768 miles) had been altered from their natural condition. There were nearly three alterations per stream mile and the average length of a channel alteration was 664 feet. The most serious loss to fish production resulted from the nearly 10% decrease in the natural length of the streams. There were over 5.5 times as many catchable-sized trout and nearly 10 times as many whitefish censused in natural

channels as in the altered channels. Since this was a fisheries study, other wildlife or wetland implications were not discussed; but the study data could show that the meanders and vegetated edges--the areas of lowest water velocities and most abundant waterfowl or other wildlife food and cover--have suffered greatest attrition from the streams' alterations.

Anderson, M. E. 1963. Dugout modification study 1960, 1961, 1962. S. Dak. P-R Completion Rept. W-75-R-5 Job W-16-1-5, 19 pp. and appendix.

Stock-watering dugouts were rebuilt with shallow end modified to produce waterfowl food and cover. Nesting and brood habitat developed beneficially but grazing control is needed and the cost can be justified only in low quality wetlands habitat. In high quality natural wetlands the basic waterfowl needs are already met.

Anderson, W. L. 1948. Level ditching to improve muskrat marshes. J. Wildl. Mgt. 12(2):172-176.

Three privately owned muskrat marshes where level ditching grids were created are subjected to an economic analysis. Twenty years have passed since this paper was published and the monetary figures would not apply today, but percentages are probably still valid. Level ditching increased muskrat trapping success by 192%; the net dollar return per acre increased 259%. The additional net income after level ditching liquidated the improvement investment in two years.

Arend, P. H. 1963. Master plan for land and water use, Phase I, Grassland Soil Conservation District. Prepared by Carroll E. Bradberry & Associates, Los Altos, Calif. for Grasslands SCD, Los Banos, Calif., 33 pp., appendices.

Pages 1-18 and 28-29 discuss the wildlife resources of the Grasslands--40,000 acres of alkali flood plain in the San Joaquin Valley. Discussed are economics of recreation, waterfowl, other animal species, integrated waterfowl use and cattle grazing, mosquito abatement problems, pesticides, and a tentative management program.

Arend, P. H. 1965. Master plan for land and water use, Phase II, Grasslands Soil Conservation District. Prepared by Carroll E. Bradberry & Associates, Los Altos, Calif. for Grassland SCD, 35 pp., appendices.

Phase II expands and continues delineating the program in Phase I. A cooperative management program for the District

is described, the economics are discussed, and a detailed cost estimate is tabulated. To wetland students, the primary value of these papers lies in their general summary of the integrated and cooperative program needed for a large wetlands area of diverse interests and many owners.

Arend, P. H. 1966. Suisun Soil Conservation District, Solano County, California. Final Report, Phase I. Prepared by Simpson, Stratta, and Associates and Karl Baruth, San Francisco, for Suisun SCD, Fairfield, Calif. Sec. A and C:1-40.

A master plan for a 42,000-acre marsh in the estuary of the Sacramento and San Joaquin Rivers is presented. Section A describes the marsh. Section C, "The Wildlife Study," tells of past history and present use. Of primary interest to wetlands students are the descriptions (Sec. C, p. 28-29) of the three types of wetlands management used in the marsh for waterfowl areas; Type I, wet land-dry land (flood pre-season, drain post-season); Type II, wet land-dry land plus spring flood, flush, and drain; Type III, permanently flooded circulating pond. The advantages, faults, plants and their succession that are associated with each of these management types are discussed. Food habits studies and other biological data are presented.

Arend, P. H. 1967. Water requirements for the waterfowl of Butte Basin, California. Calif. Dept. F. & G., Water Proj. Branch Rept. No. 6, 73 pp., 10 figs., 3 map pls.

A basic data report on the waterfowl and other wildlife of this famed duck club area in Sacramento Valley, will interest wetlands ecologists primarily for the unique approach in assaying the water requirements of waterfowling wetlands (see p. 55-58). The method, too detailed for meaningful summary in this space, involves correlating land-use data with known crop-water requirements and total water supply for the area. Aquatic and marsh vegetation types are then plotted for known waterfowling areas, and water requirements are extrapolated for these areas. The requirements for a given marsh plant species are derived from State WMA records.

Arner, D. H. 1963. Production of duck food in beaver ponds. J. Wildl. Mgt. 27(1):76-81.

A draining technique makes bottoms of beaver ponds available for summer production of watergrass. Flooded ponds are leased for waterfowling. Drainage techniques: A. Make large break in beaver dam in June or July; by the time the

beaver repair the break the watergrass is mature. B. A three-log drain through the dam makes a trickle leak the beavers cannot repair; when the logs are removed in October, the beavers repair the small break in a week and the pond is ready for hunting. Costs of dam drains and watergrass planting are given.

Atkeson, T. Z. and L. S. Givens. 1952. Upland farming as a method of supplementing the natural waterfowl food supply in the Southeast. J. Wildl. Mgt. 16(4):442-446.

Describes techniques and crops used to provide supplementary food for geese and field-feeding duck species in southeastern United States.

Barstow, C. J. 1957. A comparative study of availability of waterfowl foods and waterfowl use on a series of clear and turbid farm ponds in north central Oklahoma. Proc. 11th Ann. Conf. S. E. Assoc. G. & F. Comm: 364-376.

Observation on 21 clear and 23 turbid ponds showed that, in late winter and spring, migratory waterfowl used the clear ponds 95.9% more than the turbid ponds. Waterfowl use apparently was not affected by the type of pond (open or "ravine"); pond size use-data were inconclusive. Author recommends creating and maintaining clear, productive farm ponds. (N.B. Pond turbidity in this area of Oklahoma depends on whether or not a pond is constructed on colloid clay soil.)

Bartee, L. D. 1964. Evaluation of mulch materials for establishing vegetation on small dams. J. Soil & Water Cons. 19(3):117-118.

Mulch materials tested were hay, wood pulp, and forage sorghum grown for dead litter. Hay mulch was applied by hand, 2.5 tons/A. Wood pulp was applied as slurry, 330 lbs./1,000 gals. water per acre. (N.B. Wood pulp was dyed green; proper color indicated proper depth application.) Sorghum was seeded at 20 lbs./A., grown, and littered. Cost: wood pulp highest, sorghum lowest. Wood pulp application is far speedier. Hay mulch can be applied any time but is fairly expensive and requires a lot of hand labor. Dead sorghum litter can be established only after growth and turn-in. All three types of mulch produced equally satisfactory stands of native perennial grasses. (See Atkins, 1958.)

Beard, E. B. 1964. Duck brood behavior at the Seney National Wildlife Refuge. J. Wildl. Mgt. 28(4):492-521.

A detailed and authoritative two-year study of duck broods "living in their natural environment and probably unaware of the presence of a human observer." Inter- and intra-specific behavior is recorded; the impact on non-predators as well as predatory animals is noted. Management implications of the following are discussed: importance of loafing sites to broods' daily activities; mobility of duck broods; overcrowding of rearing marshes. Author recommends developing a large number of small, well-protected marshes and ponds.

Bednarik, K. 1955. What makes a marsh. Ohio Cons. Bull. 19(1):6-7.

Marsh management on Lake Erie marshes in Ohio included water-level controls established by ditching, weirs, etc. Dragline ditches were found to be more satisfactory than those made by blasting or 'dozers. Marshes are drained in spring and summer; pump-flooded in September. Land ploughed prior to flooding produces heavy cattail stands; similar land, unploughed and flooded, produces blue joint-grass and smartweeds.

Benson, D. and D. Foley. 1956. Waterfowl use of small, man-made wildlife marshes in New York State. N. Y. Fish and Game J. 3(2):217-224.

During 1953, 1954, and 1955, studies on 559 small marshes compared their value as waterfowl habitat. Specific stages of plant succession correlate with the marsh's attraction to waterfowl. Marsh tends to decline after three years of flooding. Small areas are more productive than large marshes. An average 5-acre marsh will support two breeding pairs of ducks.

Berg, P. F. 1956. A study of waterfowl broods in eastern Montana with special reference to movements and the relationships of reservoir fencing to production. J. Wildl. Mgt. 20(3):253-262.

The impact of cattle grazing on waterfowl production on reservoirs in eastern Montana was observed for two years in 12 fenced and 12 unfenced ponds. Unstable water levels obscured the data and no definite conclusions were reached, but it appears that larger, fenced ponds with more vegetation produce more ducks.

Bernstein, L. 1958. Salt tolerance of grasses and forage legumes. USDA Agr. Inf. Bull. 194. 7 pp.

Salt tolerance is the degree to which a crop can produce satisfactory yield on salty land. The primary effect of salt is to decrease the availability of water. Tolerance of different grasses and forage legumes ranges from as little as 2 to 3 millimhos up to 12 or more. Millimho is an expression of salinity based on conductivity of saturation extract of soil. Saltgrass, bermudagrass, and birdsfoot trefoil are classed under "good salt tolerance" (12 to 6 millimhos); dallisgrass, sudan, and alfalfa are examples of "moderate salt tolerance" (6 to 3 millimhos); many of the clovers--alsike, red, ladino--have "poor salt tolerance." The pamphlet stresses that not all varieties of a forage plant species are similarly affected; nor is the effect of salinity the same in all species. Since salinity checks vegetative growth, a salt-tolerant forage plant grown on saline land may even be richer in certain vitamins and nutrients than the same plant grown on non-saline soil. However, excessive salt pickup may cause scours in cattle. The decrease in yield and drop in palatability of salt-coarsened forage may offset the nutrient enrichment. (N.B. These factors point up the benefits derived from short-term, intensive grazing in managing saline wetlands in an integrated cattle/waterfowl program. P.H.A.)

Biswell, H. H. and A. M. Schultz. 1958. Effects of vegetation removal on spring flow. Calif. Fish and Game 44(3):211-230.

Plant cover manipulations in springs and stream flows find that: 1. Conversion from deep-rooted species (trees and shrubs) to shallow-rooted (grass) makes water below root zone available for spring flow; 2. Removal of transpiring surface of deep-rooted plants immediately increases spring and stream flow; 3. Practices which seal off or decrease soil porosity and increase the surface run-off retard or stop spring flow.

Boyko, H. 1967. Salt-water agriculture. Sci. Am. 216(3):89-96.

An important paper; the techniques outlined may have wide application in the saline sandy wetlands of the Southwest. Experiments in Israel indicate that many plants can be irrigated with salty water, even at oceanic strength, if the soil is sandy. In non-sandy soils salt accumulates past all plants' salt tolerances. The author holds that if sand grows salt-fixing plants the sand will desalinate as the crop is harvested and removed. Other reasons are given for sandy soils desalinizing: Water percolates

quickly through sand and gravel. Plant root systems will aerate well in this environment, since sand and gravel possess larger interstitial spaces than clay or silt soils. MgCl and NaCl are easily soluble. In irrigated sandy soils these salts wash down to deep layers. On the other hand, if solution movement is upward, due to evaporation or capillary action, the NaCl and MgCl will form surface crystals. In either case, the salts in sandy soil will not concentrate at midzone in amounts dangerous to feeder roots or root hairs. Finally, sodium ions are not adsorbed on sand crystals but adsorb readily in clay particles which then swell and become impermeable. The midzone becomes salty and the plants die. The author describes the condensation of "subterranean dew" to supply fresh water to feeder roots; the plant viability resulting from equalized osmotic pressures or "ionic environment balance;" enhanced plant vitality from the high nutritive value of salty water. Global salt circulation is discussed. Various field experiments and relative salt tolerances are listed for several cereals, legumes, oilseeds, sugars, fibers, forage grasses, and fodder.

Bue, I.-G. 1956. The ecology of waterfowl populations on stock ponds in western South Dakota. Ph.D. Thesis, Univ. Minn., 163 pp. Diss. Abstr. 16(6).

Stock ponds built since 1937 represented a new breeding area that produced about 200,000 waterfowl annually. Over 80% of breeders were blue-winged teal, mallard, and pintail. Also breeding were shoveller, gadwall, and baldpate. Diving ducks rested but did not breed on the ponds. Fifty-five percent of nests were successful, and 65% of pairs brought off broods. Overgrazing destroyed shoreline vegetation, thereby reducing duck populations and nesting. High turbidity and overpopulations of fish reduced waterfowl usage and excluded some species of waterfowl. Management recommendations: Keep grazing intensity within the carrying capacity of the range; fence, selectively, ponds that are and will continue to be overgrazed; control population size of rough fish.

Bue, I. G., L. Blankenship, and W. H. Marshall. 1952. The relationship of grazing practices to waterfowl breeding populations and production on stock ponds in western South Dakota. Trans. 17th N. Am. Wildl. Conf.:396-414.

A two-year study shows that overgrazed range around stock ponds and pond margins has low waterfowl value and production. In study area, short-grass prairie of South Dakota, when grazing was less than 15 cow-days/acre stock

pond shorelines were grassy and waterfowl production increased. Shorelines went to mud when overgrazed and waterfowl production dropped. Management recommendations: hold grazing to 27 acres per cow or 15 cow-days/acre per year; fence off portion of overgrazed shorelines to exclude cattle.

Burgess, H. H., H. H. Prince, and D. L. Trauger. 1965. Blue-winged teal nesting success as related to land use. J. Wildl. Mgt. 29(1):89-95.

Three-year study on national refuge in Iowa located 111 nests. Kentucky bluegrass and alfalfa were preferred cover on 77% of nests. Nesting density and nesting success are compared on grazed grasslands (1:10/A.; 47%) and on ungrazed grasslands (1:17/A.; 14%). Grazed grasslands and hay fields were equally productive nesting habitat for blue-winged teal. Controlled grazing on refuge resulted in 1:9/A., 46%. (N.B. More fertile soils produced more, both of wildlife and cattle use.)

Burman, R. D., M. A. McNamee, and R. L. Lang. 1958. Reservoirs for range stockwater development. Univ. Wyoming, Agr. Expt. Sta. Circ. 67, May 1958, 6 pp.

Discusses need for range stockwater development in Wyoming and describes briefly the small stockwater dam, the pit reservoir, and the stockwater guzzler. Offers suggestions for renovating silted small reservoirs. Use of development for waterfowl or other wildlife is not mentioned.

Chabreck, R. H. 1960. Coastal marsh impoundments for ducks in Louisiana. Proc. 14th Ann. Conf. S. E. Assoc. G. & F. Comm.:24-29.

Uncontrolled tidal marshes on the Gulf Coast were impounded in a waterfowl management program. Impounded areas produced a larger variety of plants and high value duck foods predominated, in contrast to the low value tidal climax previously found. Fresh, brackish, and salt water impoundments were established. Non-producing turbid ponds, dried until mucky soil surface became cemented, maintained clear, non-turbid water upon reflooding and produced heavy widgeongrass stands. Construction details and costs of impoundments are given. Only those areas where soil quality will support levees should be impounded.

Chabreck, R. H. and C. M. Hoffpauir. 1962. The use of weirs in coastal marsh management in Louisiana. Proc. 16th Ann. Conf. S. E. Assoc. G. & F. Comm.:103-112.

Weirs were built in drainage systems of brackish and tidal marshes to influence vegetative growth by altering salinity, turbidity, and water levels, and by reducing tidal action. Findings: greatest effect is stabilizing water; salinities were normally only slightly affected. In periods of drought, salinity fluctuations could be greatly influenced or stabilized, as desired. The same plant species continued to grow after the weirs were built; however, in areas where salinity did not fluctuate drastically, aquatic vegetation grew more abundantly behind the weirs. (N. B. Weirs were built instead of impoundments (See Chabreck, 1960) because the soils of this coastal area were too fluid for successful levee construction.)

Chamberlain, E. B., Jr. 1960. Florida waterfowl populations, habitats and management. Fla. Game and Fresh Water Fish Comm., Tech. Bull. No. 7, vi and 62 pp.

Soils, geology, vegetation, climate, and water characteristics are reviewed. Water level fluctuations are important for waterfowl food utilization.

Chapman, V. J. 1938. Studies in salt marsh ecology; Section I to III. J. Ecol. 26:244-279.

Discusses the physiography and environmental factors in the principal salt marshes of England. Tidal influences on the distribution of vegetation are analyzed with regard to length of submergence and exposure per annum, and submergence in daylight. Water tables, soil aeration and drainage, root systems, tides, and tidal cycles are discussed. This is a definitive, basic study of salt marsh ecology.

Chapman, V. J. 1940. Studies in salt marsh ecology. Section VI and VII. Comparisons with marshes on the east coast of North America. J. Ecol. 28:118-151.

Environmental factors such as physiography, tides, water table, aeration, drainage, salinity, and moisture are discussed in detail. This scholarly and lengthy study by a leading British authority on salt marsh ecology is a good general survey of New England salt marshes.

Chenault, T. P. 1940. The phenology of some bobwhite food and cover plants in Brazos County, Texas. J. Wildl. Mgt. 4(4): 359-368.

Although not concerned with wetlands, this paper provides an example of a technique for phenological studies. Based on weekly field observations over a 19-month period, the study found seven distinct "waves" of vegetation, segregated on the basis of period of flowering: in winter, one wave; in spring, three; in summer, two; and in fall, one. Many of the plants listed are also common in marginal or seasonal wetlands.

Cofer, H. P. 1957. Effects on plants and waterfowl when salt water is introduced into a freshwater pond. Proc. N. E. Sec. Wildl. Soc. et al.:1-3.

A fertile freshwater lake and waterfowl sanctuary aroused local ire due to stink of decayed vegetation and to heavy aquatic weed growth that impeded motor boats. A law was passed to compel pumping of seawater into the lake. A goal of 1½% sea salinity was prescribed and pumping began in 1954. Salinities held between 1½% and 2½%. Effects: widgeongrass increased; other aquatics disappeared; vegetation generally decreased; waterfowl use declined--Canada geese by 50% and canvasbacks by 66%. But stinks abated and motor boats had clear going.

Cook, A. H. 1958. Waterfowl marshes and menus. N. Y. State Cons., Feb.-Mar. 1958:16-18, 40.

This excellent "popular" article encapsules in laymen's terms the following: Waterfowl food plant production is a problem of wetland farming; marsh soils have a high level of available plant nutrients. Non-productive marshes may result from biochemical change in marsh soils after flooding. An example is the increased amount of soluble iron and manganese--overdose results in a "sterile" marsh. Iron and manganese become soluble in absence of oxygen. When marsh is drained these metals, exposed to air, oxidize to insoluble compounds. Periodic marsh drainage is hence seen to be a management tool, since the process is reversible. The anaerobic bacteria that create soluble Fe and Mg are most efficient in slightly acid soils. Liming to alkalize marsh produces a favorable bed for food plants. An illustrated list of a few favorite duck food plants and a brief ecological description of each are included.

Cook, A. H. and C. F. Powers. 1958. Early biochemical changes in the soils and waters of artificially created marshes in New York. New York F. & G. Journ. 5(1):9-65.

Two years of study on shallow-water environments, in six artificially created marshes, indicate that marshes surrounded by good agricultural soils are more productive than those surrounded by degraded lands, and that soils of marsh basins are more fertile per se than those of contiguous drain areas. Strong thermal and chemical stratification is noted in waters of marshes. Management considerations suggested: Frequent drainage may be dangerous and the need is to remove surface, as opposed to sub-surface, waters in excess runoff. Drainage, to be effective, must aerate marsh soils. This reduces the organic matter and consequently keeps excessive amounts of soluble iron and manganese from appearing later in pond waters. (See USDI 1964, Waterfowl Tomorrow, for A. H. Cook, p. 569 ff.)

Cottam, C. and W. S. Bourn. 1952. Coastal marshes adversely affected by drainage and drought. Trans. 17th N. Am. Wildl. Conf.:411-421.

The economic and ecological considerations of marsh drainage are discussed in terms of habitat destruction, recreational and agricultural uses, as well as mosquito abatement.

Cowardin, L. N. 1965. Flooded timber as waterfowl habitat at the Montezuma National Wildlife Refuge. Ph.D. Thesis, Cornell Univ., Diss. Abstr. 26(8):4932.

Flooded hardwood timberlands are compared, as waterfowl habitat, with adjacent cattail marsh. Factors compared are: aquatic plant production, waterfowl use, waterfowl production. Aquatic plant production was physically hindered by fallen timber that prevented water circulation and dispersal of drifting plants. However, environmental factors (water depth, carp, etc.) had a greater effect on the plant community than presence or absence of timber. Certain species of waterfowl, particularly black duck and mallard, used the area heavily. Widgeon were restricted to timbered pools. Timbered pools produced up to .17 nests/A. Installation of wire nesting forms pushed nesting density to .33/A. Only redheads nested in cattail; mallards and black ducks in timber. Conclusion: Flooded timber at Montezuma NWR provides valuable waterfowl habitat. Abundant invertebrate food was found associated with duckweed, itself a good food. Fallen logs provided loafing sites, snags and stumps nesting sites. Lack of vegetative cover was the principal limiting factor, particularly in brood use.

Critcher, T. S. 1958. Production of waterfowl foods by the summer drawdown method. N. C. Wildl. 22(7):15-19.

Small private marshes in North Carolina are managed for waterfowl by summer drawdown. Size, location, control of water levels, and satisfactory food plants are discussed. In this area the best plant for the dry soils of drawdowns is browntopmillet.

Davis, T. G. 1967. Planned waterfowl habitat. Soil Cons. 32 (8):174-175.

A general resume of Sauvie Island SCD, Oregon, waterfowl development on private duck clubs and the state game area.

Davison, V. E. and W. W. Neely. 1959. Managing farm fields, wetlands, and waters for wild ducks in the South. USDA Farm Bull. 2144, 14 pp.

Management details presented are largely restricted to a regional application; the management principles are not. Adequate water controls and management, noxious plant control, food and cover plantings, regulating water depths, using grazing and burning as marsh management tools--these are sound principles anywhere. The bulletin also discusses brackish water ponds and their management, and offers hunting suggestions.

Day, A. M. 1966. Wildlife habitat management as a means of increasing recreation on public lands. U. S. Bur. Land Mgt., Mar. 4, 1966, 73 pp., 63 pls.

Pages 10-21 of this report discuss Montana's waterfowl, stock ponds, and dugouts, and the still unresolved question of the economic feasibility of fencing stock ponds against cattle for waterfowl production. Evidence is cited that fencing benefits cattle by providing a source of clear, cold drinking water delivered through dam by base-level 2" pipes. Pipes are installed by bulldozer push on old dams with no outlet. Author recommends another two stock dams to every three square miles in this prairie land.

Edelman, C. H. and J. M. Staveren. 1958. Marsh soils in the United States and in the Netherlands. J. Soil and Water Cons. 13(1):14-17.

A discussion of the chemical, physical, and hydraulic characteristics of various marsh soils, their best use, which are most easily reclaimed and how. The writers suggest that in the long run only poorest types--"cat clays," etc.--will be considered as best left to wildlife use. Economic

pressure will force reclamation of others to higher cash value uses. This article, reflecting the Dutch professional marsh soils experts' points of view, repays thoughtful study. The authors find much lacking in our wasteful techniques of water management.

Eggleton, F. E. 1939. Fresh-water communities. Am. Midl. Nat. 21(1):56-74.

Discusses philosophically the ecological concepts stressing habitat versus organisms in categorizing aquatic communities.

Ermacoff, N. 1965. Marsh and upland management practices at the Mendota Waterfowl Management Area. Calif. Dept. F. & G., Region IV, 18 pp., map, photos. Mimeo.

This is a practical, down-to-earth report by the resident manager of a large state game area in southern California. Emphasis is on control of undesirable winter emergent plants and on establishment and propagation of natural waterfowl food plants. Control by disking costs $3.00 per acre. This is the least desirable control method because of the cost, adverse effect on desirable species, and the extra irrigation involved. Flooding in winter, before first weeds emerge, is very successful but good water control structures are needed. Burning in late April or May on dried marsh is moderately effective; cost is $1.50 per acre. Sheep grazing has been an extremely effective and profitable way to control certain types of marsh vegetation. In spring and early summer, sheep will graze vegetation to the bare ground, keep ditches clean, firm levees, and compact ponds, as well as provide fertilizer. Grazing must be early and intensive to get these results. A grazing lease on 5,000 acres from March 1 to July 1 earned the State $16,153. To control cattail all the above techniques are used, except sheeping. Disking or shredding, to be effective for cattail control, must be done in late summer. The use of "isolation" levees to control cattails and other plants is described. On Mendota WMA, spring emergents generally provide the best food plants. Mud flats or very shallow water (1") from March to June permit volunteer growth or provide seedbeds for aerial planting. Experience shows that, although natural foods produce less poundage than cultivated barley or rice, natural emergents last longer without deterioration and so hold ducks longer.

Fleming, W. B. 1955. An inventory of waterfowl food plants in Arizona. Ariz. G. & F. Dept. Fed. Aid Proj. W-70-R-3-WP1-Job 2. Completion Report, Oct. 1955, 11 pp.

A Pittman-Robertson Project report, lists 47 waterfowl food

plants, their abundance, use, other data, plus distribution of these plants in Arizona. The report notes little waterfowl use of agricultural lands in northern Arizona; light gun pressure permits normal wild food habits. In southern Arizona mallard, pintail, and baldpate are the main species; they feed on crops at night and stay on refuges in daytime.

Fleming, W. B. 1961. Land development, sharecrop, and lease agreements for waterfowl in Arizona. Proc. 41st Ann. Conf. W. Assoc. F. & G. Comm.:147-150.

Arizona, marginal waterfowl habitat in most areas, is attempting to restore waterfowl habitat by leasing state-owned or controlled lands to sharecroppers who would maintain a part of the leased land in waterfowl food and cover. A brief history of the leasing procedures, details, and development is given. No specifics of cropping or land use are cited, but authors feel the program is expanding adequately.

Geib, J. R. 1957. Do closed reservoirs make better hunting? Colo. Outdoors 6(6):21-23.

Closures of Colorado's reservoirs to waterfowling in 1956 engendered some complaints. Restrictions were eased moderately in 1957. Author asserts that closures really protect waterfowl while continuing to provide ever larger bags (see Hay, 1956).

Generosoff, V. T. 1934. The culture of food and cover plants for waterfowl. All. Union Coop. Assoc. Publ. Ofc., Leningrad, 128 pp.

In Russian. Lengthy abstract in Wildlife Review 3:16-19. The author finds that food and cover plants for waterfowl are an urgent problem in game management in USSR; barren or depleted wetlands can be restored; basic ecological waterfowl research is needed. Plant groups and habitat conditions are similar in United States and Russia.

Givens, L. S. and T. Z. Atkeson. 1957. The use of dewatered land in southeastern waterfowl management. J. Wildl. Mgt. 21(4):465-467.

"Dewatered land" is land flooded during cool-weather period but drained during all or part of plant-growing season. Green timber reservoirs, particularly "pin-oak" stands provide one type of dewatered land that is cheap and easy to develop and to manage, and that is highly productive both for timber and waterfowl. Open dewatered land management is more involved; it requires land clearing,

preparation and seeding of waterfowl food and cover. The authors suggest planting higher ground to row crops of corn, grain sorghum, and soybeans. Lower elevations should be broadcast to millets, buckwheat, milo, etc. (N.B. In area of study, Tennessee Valley, summer irrigation is not needed for crop production. The Southwest is a different story. P.H.A.)

Goldstein, J. H. 1967. An economic analysis of the wetlands problem in Minnesota. Ph.D. Thesis, Univ. Minn., Diss. Abstr. 28(12-1):4799-A.

An economist makes a minutely detailed study of the problem and comes up with: "The most striking conclusion is that capital subsidies have had little influence on the drainage of wetlands. The crucial factor in promoting reclamation being the support prices for agricultural output. In general it was found that very temporary wetlands play an insignificant role in the birds' environment. (Sic. P.H.A.) Consequently, there is no divergence between private and social costs and benefits with regard to these lands and the competitive allocation is the social optimum." He goes on to "wetlands of intermediate durability" and "permanent wetlands." One statement I can concur with "...the investment cost involved in reclamation is prohibitive if perfectly competitive farm prices prevail, but the availability of crop price supports is sufficient to induce drainage of some permanent marshes."

Goodwin, H. A. 1962. Water development and waterfowl management. Proc. 42nd Ann. Conf. W. Assoc. F. & G. Comm.:102-111.

Water development projects for irrigation, power, or flood control are often deleterious to waterfowl, unless waterfowl development and management practices accompany the project. Numerous cases are cited where such programs had good results: Columbia Basin, Wash.; Mittry Lake, S. W. Arizona; Bunny Reservoir, Arizona; Storrie Irrigation District, N. E. New Mexico; Ocean Lake, central Wyoming; Springer Reservoir, Wyoming; Strike Reservoir, Idaho; Overton W.M.A., Lake Mead, Nevada; McKay, Cold Springs, McNary, and Fern Ridge Reservoirs, Oregon; San Luis Wasteway, California, are currently functioning. Management programs for each site are briefly outlined. Other planned cooperating projects are cited. Tables listing current projects by state, name, project, acreage, agency and function are appended.

Greenwell, G. A. 1952. Farm ponds, their utilization by wildlife. Mo. Cons. Comm. P-R Report 6, 14 pp.

Fencing around farm pond to exclude grazing develops "ideal wildlife cover." Usually a fenced-off area from 1 to 1.5 acres is sufficient. Areas smaller than this produce too little food or cover for sustained use. Ponds as small as .25 acre, if properly located and protected, may receive heavy wildlife use. A series of species-use graphs and a detailed use summary are presented.

Gunter, G. 1956. Some relations of faunal distributions to salinity in estuarine waters. Ecology 37(3):616-619.

The distribution of certain estuarine animals--crustaceans, fish, and mollusks--is influenced by water salinity. Differential tolerances are tabulated. Author suggests that the chloride content of water is the determinant.

Hall, G. E. 1952. Farm ponds for cattle or for fish. Okla. G. & F. News 8(5):4-6.

Stock and fish are incompatible, since cattle roil water and thus kill fish. However, fencing the pond and allowing cattle access only to a small segment of margin may be feasible. Author believes 2-acre fish pond is minimum size useful.

Halsam, S. M. 1965. Ecological studies in the Breck Fens; vegetation in relation to habitat. J. Ecol. 53:599-619.

A detailed and erudite work on English fen land. Two types of fens have been distinguished: headwater fens with many springs and non-silty soils poor in nutrient; and valley fens, with few springs and with silty soils which may have high fertility. The dominant vegetation types are given for each area, as well as the effects of the water table and human interference. Apart from these two latter factors, the vegetation is determined principally by differences in nutrient, mainly due to the amount of silting. Drying and disturbance also affect the nutrient status.

Hamor, W. H., H. G. Uhlig, and L. V. Compton. 1963. Ponds and marshes for wild ducks on farms and ranches in the northern Plains. USDA Farm Bull. 2234, 16 pp.

Although elementary in language and very general in treatment, this pamphlet comprehensively reviews accepted marsh management practices applicable to the northern Plains and summarizes methods of improving natural ponds and marshes,

building new marshes, improving stockwater ponds and dugouts. The authors advocate weed control, clearing and potholing dense vegetation, planting food and cover, grazing control by fencing, carp control, and predator control. (The recommendations for avian predator control are questionable. P.H.A.) Disease control is not mentioned, but some of the management practices suggested (straw bales for loafing sites, leaving cut vegetation in ponds) could lead to disaster in alkali country with high botulism potential.

Harris, S. W. 1954. An ecological study of the waterfowl of the Pothole Area, Grant County, Washington. Am. Midl. Nat. 52(2):403-432.

This is a detailed ecological study of an area that no longer exists; it was inundated by the construction of O'Sullivan Dam as a part of the Columbia Basin Irrigation Project.

Harris, S. W. 1957. Ecological effects of drawdown operations for the purpose of improving waterfowl habitat. Ph.D. Thesis, Univ. Minn., Diss. Abstr. 17(9):1857.

This detailed study cites the year-by-year effect upon the marsh vegetation; notes benefits (increased sago and other foods), detriments (botulism hazard, weed encroachment); and describes effects of drawdowns at variously timed cycles. Suggests that drawdowns be used as a specific tool, with proper control and study, not as a panacea.

Harris, S. W. and W. H. Marshall. 1963. Ecology of water-level manipulation on a northern marsh. Ecology 44(2): 331-343.

Marsh drawdowns at Agassiz National Wildlife Refuge, Minnesota, show that the five types of vegetation developed on mudflats during the first year were influenced by seed availability, soil type and moisture, season and duration of drawdown, and the amount of stranded algal debris. The more the area combined early-season drawdown, rich soil types, slow rates of mud flat drainage, and small amounts of stranded algae, the greater was the development of emergent aquatics. A second year of drawdown developed greater amounts of upland and shoreline weeds, and fewer emergents. Areas exposed before August the first year lost emergent cover the second year, while the reverse occurred on areas exposed later in the first year. Upon reflooding, mudflat and shoreline annuals were eliminated and marshes of cattails, soft-stem bulrush (Scirpus validus), sedges,

spikerush, willows, and aquatic annuals developed in the first year. Development of these areas in subsequent years was determined by the residual vegetation and the depth of the restored water. Soft-stem bulrush was destroyed by flooding with over 15" of water in 3 years and in any continuously flooded area in 4-5 years. Common cattail was gone from continuously flooded areas in 4-5 years. Narrow-leaved cattail remained unchanged in 24" of water throughout 5 years of flooding. Depending on water depth and cover type, one-or-two-year drawdowns at 5-10 year intervals are required to maintain emergent marshes at the refuge, with the possible exception of stands of hybrid cattail. Sago pondweed responded well in the first year of reflooding (perhaps because of changes in soil chemistry and nutrient availability). Less desirable growth took over during the third and fourth years.

Hay, K. 1956. Closing reservoirs for better hunting. Colo. Outdoors 5(6):18-20.

In 1956 Colorado closed certain reservoirs to hunting above high water line, in order to provide a protected rest area for waterfowl. Besides providing needed refuges, other expected benefits were: better adjacent pass-shooting, less crop depredation, higher quality hunting, increased hunter safety by keeping hunters off frozen reservoirs. (See Geib, 1957, Sec. B.)

Hinde, H. P. 1954. The vertical distribution of salt marsh phanerogams in relation to tide levels. Ecol. Mono. 24: 209-225.

Tidal salt marshes in south San Francisco Bay support three major plant associations: (a) Spartinietum (cordgrass dominant); (b) Salicornietum (pickleweed dominant); and (c) Distichlidetum (saltgrass dominant). Range of each association: (a) 5.4 ft. to 8.4 ft. above MLLW; (b) 6.4 ft. to 10.3 ft. above MLLW; (c) 7.15 ft. to 10.3 ft. above MLLW. Duration of inundation establishes lower limits of range. Competition, water supply, etc., establish upper limits.

Hoagland, D. R. 1949. Fertilizers, soil analysis, and plant nutrition. Univ. Calif. Agr. Ext. Svc. Circ. 367, 24 pp.

The brief, simple resume stresses that chemical soil analyses tell little of the soils' capabilities and needs. Acid and alkaline soils, and ways to balance them, are discussed.

Holte, K. E. 1966. A floristic and ecological analysis of the Excelsior Fen complex in northwest Iowa. Ph.D. Diss., Univ. Iowa, Diss. Abstr. 27(5):1377-B.

Twenty-four calcareous fens in Dickinson Co., Iowa, are evaluated floristically and ecologically to determine how and why a fen is different from other wetlands. As a result of intensive and complex analyses and evaluations, the following definition is derived: "The term 'fen' refers to a calcareous, springy site located either on a prairie hillside or in a lowland. Cold, highly calcareous water seeps up through peat which has formed above sand aquifers penetrating impervious clays." Miniature terraces formed by damming action of the peat retain the neutral-to-alkaline water in small pools which have poor drainage. The black alkaline peat is a major factor in differentiating a fen from a bog, which by definition is underlain with acid peat. Although the vegetation is similar to other wetlands, certain calcicolous species are peculiar to a fen habitat.

Hovind, R. B. 1949. Controlled burning of public hunting grounds. Wis. Cons. Bull. 14(4):13-15.

Controlled fires at Horicon Marsh, Wisconsin, remove plant debris from pond basins, create potholes, stimulate new growth, develop feeding and resting areas for geese, control alder and willow growth, break up monotypic vegetation stands, reduce chance of wildfires.

Hubbell, D. S. and J. L. Gardner. 1944. Some edaphic and ecological effects of water spreading on range lands. Ecology 25(1):27-44.

Primarily a study on range land in New Mexico, this paper has some minor interest to wetlands ecology in its descriptions of plant successions, resistance of vegetation to silting, and soil responses.

Hutchins, W. A. 1956. Irrigation water rights in California. Univ. Calif. Agr. Ext. Svc. Circ. 452, 55 pp.

Restricted to California in detail, this pamphlet has information of interest to wetlands technicians in other western states, if only for the glossary that defines legal terms such as: watercourse, ground water, subflow, percolating water, spring, foreign water, water right, riparian right, appropriative right, correlative right, prescriptive right, pueblo right, etc. However, check with your own state for variations from the California code.

Jenni, D. A. 1956. Pothole water levels in relation to waterfowl breeding populations and production. M. S. Thesis, Utah State Agr. Coll., Logan, Utah, vii and 55 pp., 12 figs. Wildlife Review 85(48).

Study in Day County, South Dakota, 1954, followed four years of work by others. Findings: Small, ephemeral potholes served breeding pairs; large, durable ponds served broods. Levels of use of various pothole types in wet or dry years are discussed.

Jensen, G. H. 1940. The relation of some physical and chemical factors of the soil to the productivity and distribution of certain waterfowl food plants at the Bear River Migratory Waterfowl Refuge. M. S. Thesis, Utah State Agr. Coll.

Available from Utah State Agr. Coll. files. Title listed in Wildlife Review 59:52. Not reviewed by P.H.A. but the citation keeps turning up in other bibliographies.

Jervis, R. A. 1964. Primary production in a freshwater marsh ecosystem. Ph.D. Thesis, Rutgers State Univ., Diss. Abstr. 25(4):2189.

Primary productivity was studied on four freshwater marshes in New Jersey. Conclusions: In general, early summer was the most productive period, following a springtime development of photosynthetic capital which varied from gradual to rapid--most rapid in rhizomatous cattail community in which there was a marked recall of stored foods. Production thereafter decreased, except for a slight autumnal spurt. The estimated average and maximum productivities were among the highest recorded for natural vegetation. Soil colloids and the groundwater nutrient level were high. It is suggested that these variables, along with abundance of soil moisture and an unusually well adapted flora, are the major factors contributing to the high productivity in the marsh.

Johnsgard, P. A. 1956. Effects of water fluctuation and vegetative change on bird populations, particularly waterfowl. Ecology 37(4):689-701.

Study in the potholes, Washington, determines the biotic effects of water fluctuation caused by dam construction. Potholes are classed by degree of change resulting from the construction. Conclusions: Flooding has reduced total waterfowl population and concentrated the remaining breeding population into smaller remaining potholes. Rabbitbrush, the primary nesting cover, is reduced in abundance.

Migratory waterfowl populations are slowly building up on reservoir, mallards leading in build-up. Food plants of importance are three-square bulrush, saltgrass, as well as peas, corn, and wheat from nearby croplands.

Kadlec, J. A. 1960. The effect of a drawdown on the ecology of a waterfowl impoundment. Ph.D. Thesis, Univ. Mich., Diss. Abstr. 22(8):2065.

Backus Lake in northern Michigan was studied during summers 1956 and 1957 for pre-drawdown, 1958 for drawdown, and in 1959 for post-drawdown. Soil, water, vegetation, invertebrates, and waterfowl were noted. Drawdown increased soluble plant nutrients. Aerobic nitrification increased soil nitrates. Most favorable nutrient changes occurred when organic soil remained moist or even saturated during drawdown. Leaching and low rate of organic decay accompanied total drought. Invertebrate aquatic life remained reduced one year after reflooding. Common marsh perennials were little altered. Submerged aquatics were reduced even after one year of reflooding. Wetland food plant production during drawdown was disappointing. By 1959 waterfowl use increased, due to abundant pondweed regrowth attributed to increased soil nutrient. Author feels that drawdown is a useful tool, but no panacea, in marsh management; use must be based on individual situation.

Kadlec, J. A. 1962. Effects of a drawdown on a waterfowl impoundment. Ecology 43(2):267-281.

A detailed study of Backus Lake, Michigan, finds three major effects from drawdown in an unproductive marsh: first, a temporary abundance of food in the seed of wetland plants; second, emergent cover reestablishes; third, soil may improve from aeration and, consequently, aquatic food production will soar after the area is reflooded. However, increased soil fertility depends on retaining adequate soil moisture despite surface water absence. Reduce water level just enough to expose soil surface. Too frequent or too severe drainage may be harmful.

Keith, L. B. 1961. A study of waterfowl ecology on small impoundments in southeastern Alberta. Wildl. Mono. No. 6, The Wildlife Society, 88 pp.

The monograph reviews five breeding seasons (1953-1957) on Ducks Unlimited ponds in southeastern Alberta, an area characterized by extreme seasonal and yearly variations in temperature and rainfall. Impoundments were built on grazing land. Terrestrial vegetation falls into three

major groups: mixed prairie, Juncus, and halophytic. Typical species in each group are: 1. Stipa comata, Carex spp.; 2. Baltic rush; 3. Hordeum jubatum and Distichlis stricta. Soils are generally sandy. Ponds have typical pondweeds and salt-tolerant shoreline emergents (cattail and bulrush). Stomach collection (221) showed that seeds and fruit of marsh plants and pondweeds were the staple diet. In fall, mallards and pintail fed on cultivated grains and field peas. Water milfoil and spikerush were found to be important foods--this is contrary to other studies.

Nesting was studied for five seasons; 806 active and 272 terminated nests were found, averaging 2.6 acres per nest. Grazing (1.2 acres per head per month--July-Nov.) did not seriously reduce nest cover. Over 50% of nests in study were destroyed by mammals, principally skunks. Duckling mortality was 24%. Average number of ducks produced each year on the area was 669. Cost data projected: during project amortization (30 years) 56¢ per duck raised, $2.07 per duck bagged; after 30 years, 8¢ and 30¢. (Economic data are interesting but debatable. P.H.A.) Management findings: Independent water controls and supply are needed for individual ponds. Removal of cattail increases waterfowl production. Recommendations: spring water level manipulation; nest island construction; elimination of mudflats; eradication of dense cattail. A mosaic of different size impoundments will make most desirable project.

King, D. R. and G. S. Hunt. 1967. Effect of carp on vegetation in a Lake Erie marsh. J. Wildl. Mgt. 31(1):181-188.

Another in a long series of papers on the carp problem in Lake Erie marshes. Findings are approximately the same as those reported 17 years earlier (Anderson, J. M., 1950).

Knight, R. R. 1965. Vegetative characteristics and waterfowl usage of a Montana water area. J. Wildl. Mgt. 29(4):782-788.

In 1956 and 1959 the vegetation was mapped on a 296-acre pond in western Montana. The pond is part of the drainage complex of a glacial basin, Freezeout Lake, where overflow and fluctuating water levels had recently been controlled. The pond has undergone typical successional changes in vegetation. Waterfowl use has increased. The vegetative changes are detailed, but without analyzing the causes, and the nest and brood counts present little new information.

Labisky, R. F. 1957. Relation of hay harvesting to duck nesting under a refuge-permittee system. J. Wildl. Mgt. 21(2): 194-200.

Share-cropped farm units on a national refuge had high duck-nest losses due to haying practices. Various cutting practices to avoid these losses are described. Leaving nesting islands; leaving edges of hayfields uncut; and delayed haying were tried and evaluated. Only delayed haying of high density nesting sites is really effective but requires compensation to tenant. The author suggests growing the first hay crop for seed.

Lamb, S. H. and R. H. Stewart. 1967. Farming for waterfowl in New Mexico. Proc. 47th Ann. Conf. W. Assoc. F. & G. Comm.: 292-295.

New Mexico lost much of its waterfowl habitat along the river valleys of the Pecos and the Rio Grande due to irrigation and reclamation projects of the 1940's and 1950's. When a disastrous waterfowl decline was evident, the state turned to "farming for waterfowl." Currently a total of over 1,000 acres of good cropland is being intensively farmed in five scattered areas. Grain is grown, harvested, stored, and fed back to waterfowl. The authors state that more naturalistic feed production methods with, perhaps, a more esthetic approach would fail to meet New Mexico's waterfowl needs.

Leisman, G. A. 1957. Further data on the rate of organic matter accumulation in bogs. Ecology 38(2):361.

In this study, the deposition rate of organic material in a northern Minnesota bog is obtained by measuring the accumulation of sediment on a length of wire laid flush on sedge mat. Organic material settles at a rate of 0.55 in. (1.40 cm) per year. These data correlate (0.54 in. per year) with prior experimentation by the author.

Loveless, C. M. 1959. Study of the vegetation in the Florida Everglades. Ecology 40(1):1-9.

Principal types of vegetation are the sawgrass, wet prairie, slough, and tree island communities. The species composition and ecology of each community are discussed. The author suggests that natural fire and drainage programs must be considered more carefully in future management decisions.

Low, J. B. and F. C. Bellrose. 1944. The seed and vegetation yield of waterfowl plants in the Illinois River Valley. J. Wildl. Mgt. 8(1):7-22.

Seed productivity of 28 waterfowl food plants was measured and the foliage production of 6 submerged species was determined. The average seed yield was 101.2 cc per square meter of plants, or about 14 bushels of seed per acre. Foliage production averaged 127 g dry weight per square meter; about 975 lbs./A. Environmental and edaphic factors, such as water depth, water transparency, and soil type affected normal yields of seeds and foliage.

Lynch, J. J., T. O'Neil, and D. W. Lay. 1947. Management significance of damage by geese and muskrats to Gulf Coast marshes. J. Wildl. Mgt. 11(1):50-76.

A definitive article describing "eatout," i.e. marsh habitat destruction, by geese and muskrats in the tidewater marshes of the Gulf Coast. Normal plant succession at various habitat sites is described; the vegetative and soil changes resulting from "eatout" are detailed; the factors that stimulate or delay recovery and the significance of this damage to cattle management and to wildlife management are discussed.

MacNamara, L. G. 1949. Salt-marsh development at Tuckahoe, New Jersey. Trans. 14th N. Am. Wildl. Conf.:100-117.

This classic paper provides a blueprint for the waterfowl and wildlife development of a controlled brackish or salt-water marsh and should be carefully studied by managers of such marshlands. The work is too detailed to abstract reasonably.

Magistad, O. C. 1945. Plant growth relations on saline and alkali soils. Bot. Rev. 11(4):181-230.

Reviews 362 papers on the above subject. Fields stressed are: classification and composition of saline and alkali soils and the physiological responses of plants grown on these soil types. In saline soils, the principal factor depressing plant growth is the decrease in available water due to high osmotic pressure of the soil solution. Water absorption is reduced as the osmotic pressure of the substrate increases. Some investigators attribute growth decrease to effect of specific ions, but ions appear to be less important than osmotic pressure. The harmful effects of reduced water intake have been attributed to salting out of cellular proteins, shrinkage of cell contents from cell wall, irreversibility of hydration of

cell contents, and interference with ion accumulation. In saline soils, plants are subjected to high concentrations of certain salts and to unfavorable salt ratios. Under these conditions, nitrogen compounds are not assimilated, carbohydrates accumulate, and growth rate is reduced. However, starch formation may also be inhibited by high chloride concentrations. In alkali soils having large contents or replaceable sodium, the soil takes on unfavorable physical properties. It disperses, does not drain well, the soil air may be low in oxygen; the soils do not "take" irrigation water. The presence of considerable amounts of salts in soils overbalances or minimizes the unfavorable effect of exchangeable sodium on the dispersion soils. When such salts are removed from a saline alkali soil the unfavorable physical effects are accentuated. A distinction is made between the characteristics of saline and alkali soils, since it is believed that the physiological reactions of a plant are different under the two sets of conditions. A plant may be tolerant to the one soil type and not to the other.

Marta, G. F. 1967. Effects of nesting cover removal on breeding puddle ducks. J. Wildl. Mgt. 31(2):236-247.

The impact of late-summer wild hay mowing on puddle ducks breeding on Lower Souris N.W.R., North Dakota, in 1961-62 was studied. Use of the mowed areas by ducks was lower than on undisturbed areas, but the difference was not statistically significant. Nest densities were greater when residual cover was undisturbed. Mowing may have redistributed, not reduced, the population. Regional water conditions may have had greater impact than mowing on local population size.

Mathiak, H. A. 1953. Experimental level ditching for muskrat management. Wisconsin Cons. Dept. Tech. Bull. No. 5, 35 pp.

The "dry" marsh portion of Horicon Marsh Wildlife Area lacks deep enough water to support muskrats during critical winter period. A grid work of level ditches supplies deep water for the muskrats' aquatic food, and for their travel and protection. Ditch spoil banks provide den sites; offer more freeze-out protection than marsh mounds. The ditches also support muskrats during summer drought. In flood, the spoil banks offer resting sites, feed areas, and shelter. Ditches also provide habitat for nesting waterfowl. Dredging was more economical than ditch blasting and gave a cleaner job. Grid works of level ditching have application to western wetlands.

Mathiak, H. A. and A. F. Linde. 1956. Studies on level ditching for marsh management. Wisc. Cons. Dept. Tech. Wildl. Bull. No. 12, 49 pp.

This six-year study measured the economic and ecological benefits of level ditching semi-dry marshland for increased muskrat production. Ditch spacing of 200 ft. gave the highest yield of muskrats per acre (22.8), as well as increased utilization by other furbearers, waterfowl, and fish. Cost of ditching in 1950's varied from $25.00 per acre for ditches spaced 400 ft. apart to $156.00 per acre for ditches 50 ft. apart.

McDonald, M. E. 1955. Cause and effects of a die-off of emergent vegetation. J. Wildl. Mgt. 19(1):24-35.

An abrupt die-off of emergent vegetation in Lake Erie marshes during winters of 1945-46 and 1951-52 is attributed to rising water level. Reed marsh species resisted until unusually high levels submerged dormant shoots. Effects of die-off: invasion of opened areas by submerged aquatics and floating-leaf forms. When water levels fell, exposed mud flats were invaded by various wetland plants, depending on time of exposure and amount of reflooding.

McFarlane, N. L. and G. L. Winright. 1951. Desert agriculture. Univ. Calif. Agr. Ext. Svc. Circ. 176, 56 pp.

The first 14 pages summarize information on desert land capabilities that will be of value to wildlife and wetland managers. Alkali soils are defined; management methods and uses are outlined.

McGinn, L. R. and L. L. Glasgow. 1963. Loss of waterfowl foods in rice fields in southwest Louisiana. Proc. 17th Ann. Conf. S. E. Assoc. G. & F. Comm.:69-79.

After lengthy analysis authors recommend that domestic rice lands be flooded as early as feasible to accommodate heavy concentration of early migrant waterfowl.

Merz, R. W. and G. K. Brakhage. 1964. The management of pin oak in a duck shooting area. J. Wildl. Mgt. 28(2):233-239.

Rarely will the western wetlands manager use the techniques discussed in this study, based on flood-plain pin oak stands of the Mississippi Valley. Pin oak acorn mast is prime duck food, but good acorn crops are cyclic. Periodic flooding during pin oak dormancy will not injure the trees, although permanent flooding kills the pin oaks. Pin oak

makes salable timber. Selective logging, leaving the best acorn producers, followed by millet planting in the clearings and then flooding made money, stabilized crops of waterfowl food, and improved hunting. For the southwestern wetlands manager, experimentation with flood resistant halophytic timber and duck-food crops may be indicated.

Meyers, A. V. 1952. Waterfowl food production in Oregon. Proc. 32nd Ann. Conf. W. Assoc. F. & G. Comm.:198-202.

Author stresses the necessity "to carry food to the waterfowl and not to expect waterfowl to come to the food." Cites success at improving Summer Lake food supply by stabilizing water levels, equalizing flows, and controlling grazing. Best success with feed crops has been with locally grown domestic species. For such crops local culture is known and a reliable, reasonably priced seed source will be available. Oregon has found that aquatic food species become over-grazed by heavy concentrations of waterfowl. The state is seeding eaten-out areas with sago pondweed but transplants, restricted by economics, must be on too small a scale for real effectiveness. The paper discusses Oregon's coastal zones, Columbia Basin, and high desert zones and presents a table of 28 domestic and wild waterfowl food plants and their use in each zone.

Miller, A. W. 1962. Waterfowl habitat improvement in California. Proc. 42nd Ann. Conf. W. Assoc. F. & G. Comm.:112-116.

Author states, "water control is a primary prerequisite of waterfowl habitat improvement" and notes that vegetative sub-climax produces most food. To reach sub-climax, the manager can drain and re-flood, cultivate, fluctuate water levels, change the salinity or alkalinity level, use fire, chemicals, and biological controls. The object is to create conditions favorable to food plants and adverse to undesirable plants. Management for cattail, hardstem bulrush, watergrass, alkali bulrush, pickleweed, sago pondwee, widgeon grass, and Olney's bulrush is briefly outlined. Biological controls, adverse and beneficial, exercised by carp, muskrat, and livestock are noted. Introduction of new plant species, such as shoal grass to Salton Sea, is discussed. This paper encapsules, clearly, several major principles of waterfowl marsh management in the western states.

Miller, W. R. and F. E. Egler, 1950. Vegetation of the Wequetequock-Pawcatuck tidal marshes, Connecticut. Ecol. Mono. 20(2):143-172.

Saline tidal marshes in southeastern Connecticut are described in detail in this scholarly monograph. Plant communities and plant succession are studied and the four upland-to-bay vegetation belts are defined. Depressions are of two kinds: salt pannes with more or less lethal concentrations of brine; and potholes of unknown genesis. The impact of mosquito ditching upon the plant community is diagramed.

Milonski, M. 1958. The significance of farmland for waterfowl nesting and techniques for reducing losses due to agricultural practices. Trans. 23rd N. Am. Wildl. Conf.:215-227.

The study emphasizes the important role played in waterfowl production by crop and pasture lands adjacent to wetlands and marshes. Farmland, in a belt ten miles deep around Delta Marsh, Manitoba, was found to be used by nesting ducks--unfortunately the paper does not cite the distances from nests to broodwater. Farming operations destroy nests. Leaving "nesting islands" in hay mowing is impracticable on private lands; mowing over nests is successful. Collecting eggs from doomed nests and artificially hatching them is useful. Partial nesting success resulted when a cooperative farmer moved the nests and eggs into an adjacent, newly mowed section of the field. About 1 out of 2 nests moved went on to hatch. In others, the hen deserted. (The western wetlands manager interested in waterfowl production may well ponder the value of adjacent upland grain or pasture to his ducks. P.H.A.)

Moffitt, J. 1938. Environmental factors affecting waterfowl in the Suisun area, California. Condor 40(2):76-84.

The waterfowl management history of a large, brackish, tidal marsh is told. Uncontrolled tidal potholes probably attracted mallards primarily. By 1870 "China" levees, followed by dredger-built dikes, began to control tidewaters. Broad, open ponds bordered by alkali bulrush attracted pintail. Deeper ponds, with widgeongrass and/or sago pondweed brought canvasback. Pickleweed on mudflats was either ploughed out or drowned, to be succeeded by brass-buttons, Cotula coronopifolia. (In 1969, the Suisun Bay is still a famous waterfowling marsh. Two State Fish and Game Refuges and over 100 private duck clubs are established on this 42,000-acre marsh. P.H.A.)

Moyle, J. B. 1945. Some chemical factors influencing the distribution of aquatic plants in Minnesota. Am. Midl. Nat. 34(2):402-420.

Minnesota aquatic flora falls into three major groups, based on water quality tolerance: soft-water flora, hard-water flora, alkali-and-sulphate-water flora. Water is classified by total alkalinity, sulfate ion concentration, and pH. Each floral group is detailed in terms of its water chemistry and floral components. The study finds that water chemistry is the most important single factor influencing general aquatic plant distribution, but that bottom soil type and the physical nature of water bodies influence the local distribution of a species within its range of chemical tolerance.

Moyle, J. B. and N. Hotchkiss. 1945. The aquatic and marsh vegetation of Minnesota and its value to waterfowl. Minn. Dept. Cons., Div. G. & F. Tech. Bull. 3:1-22.

Field work, dating back to 1917, on 522 on Minnesota's 10,000 lakes is reviewed. Senior author's intensive research on the physical, chemical, and biological factors determining the distribution of aquatic plants is discussed. There are 300 species of marsh and aquatic plants in Minnesota. The more important plants and plant groups are considered in detail in an annotated checklist. The plants' values to waterfowl and management suggestions are considered. A bibliography of 67 titles, a key to common plant species, a glossary, and line drawings of 60 species are presented.

Munro, W. T. 1967. Changes in waterfowl habitat with flooding on the Ottawa River. J. Wildl. Mgt. 31(1):197-199.

Construction of a dam at Carillon, Quebec, permanently raised the Ottawa River six feet for a distance of 60 miles. The changes in riparian vegetation and in waterfowl numbers were studied after the rise in the water level and the flooding of 4,000 acres of land. Pioneering aquatic plants were river bulrush (Scirpus fluviatilis), floating and large-leaved pondweeds (Potamogeton natans, P. amplifolius), marsh cinquefoil (Potentilla palustris), and scarlet knotweed (Polygonum coccineum). Except in flooded hardwood forest, vegetation was affected more by water depth than by previous vegetation type. Breeding waterfowl increased from 1.4 to 6.5 pairs per mile.

Neely, W. W. 1956. How long do duck foods last underwater? Trans. 21st N. Am. Wildl. Conf.:191-198.

Practical marsh management finds small value in producing quantities of grain and weed seed duck foods if these deteriorate and become unpalatable or unwholesome when the crops are flooded for forage access by waterfowl. Twenty-five commonly used duck food seeds were soaked underwater for 90 days and then tested for percentage of deterioration. Five examples: soybeans 86%, Japanese millet 57%, corn 50%, smartweed (P. pennsylvanicum) 21%, alkali bulrush 1%. Varieties of the same species had different reactions; browntopmillet strain #1--36%, strain #2--15%.

Neely, W. W. 1958. Irreversible drainage--a new factor in waterfowl management. Trans. 23rd N. Am. Wildl. Conf.: 342-348.

Many wet coastal marshlands can never be drained for wildlife, pasture, or cropland. These marshes have sulfides in the soil, and when such soils (cat clays) are drained and dried the sulfides oxidize to sulfates and sulfuric acid. The soil then becomes too acidic to grow useful plants. Even re-flooding thoroughly drained and dried cat clays will not reverse the chemical process. The pH of flooding waters drops to 2.0 - 3.0, acidic and toxic to most forms of aquatic life. To lime the soils is not feasible. Cat clays are agriculturally limited to a rice-type culture that does not require deep drainage or prolonged drying out of fields. Wildlife use is also restricted to the same type of management. These brackish water areas will grow waterfowl foods such as widgeongrass, and will support commercial crops of shrimp, oysters, or fish, the author states.

Neff, D. J. 1957. Ecological effects of beaver habitat abandonment in the Colorado Rockies. J. Wildl. Mgt. 21(1): 80-84.

Abandonment of a pond by beavers results in abandonment of the area by waterfowl, muskrats, and trout; elk and deer are little affected; no significant effect is noted on other species of mammals and birds. Abandoned beaver ponds, where physically stable, are quickly invaded by grasses and sedges, and within a few years are valuable grazing and forage lands for livestock and wildlife. Author notes that breeding ducks on the high mountain streams of Colorado are restricted to beaver ponds and will not be found on abandoned beaver ponds. He advances no reasons why the ducks shun old beaver ponds.

Nelson, N. F. 1954. Factors in revegetating saline marsh areas. Proc. 34th Ann. Conf. W. Assoc. F. & G. Comm.:258-263.

This important paper states that in saline soils the principal factor depressing plant growth is the decrease in available water due to the high osmotic pressures of the soil solution. If salt concentrations are reported only on a weight basis (ppm or % in soil) two principles are masked: one soil may normally contain more water than another; one salt may exert more osmotic pressure in the soil solution than another. Best measurement is found to be the electrical conductivity expressed in millimhos/CM. Since high concentrations of salts are often accompanied by waterlogged conditions, the ability of a plant species to withstand excessive water in the root zone may be mistaken for true salt tolerance. Some plants have low salt tolerance in germination, high tolerance in later stages. Plants may be able to grow through salt concentration zones; or to establish growth in low concentrations of spring and withstand subsequent high concentration due to surface-evaporation. An eight-year study in Utah finds alkali bulrush highest, and cattail second, in salt tolerance among emergents. Samphire (pickleweed, Salicornia sp.), saltgrass, and bassia (Echinopsilon sp.), in that order, had highest tolerance among non-emergents. For emergents growing in water, salinities were lowest at soil surface and increased with depth. Non-emergents (no water above soil surface) had soil salinities highest on soil surface, due to salt concentration by evaporation from a shallow water table; salinities decreased with soil depth. Plant succession was rapid at Ogden Bay Refuge and was aided by flooding through culverts and small dike systems. Soil surface salinities were reduced, alkali bulrush and cattail invaded shallow flood areas. Permanent water produced first muskgrass, succeeded by sago pondweed.

Nelson, N. F. 1955. Factors in the development and restoration of waterfowl habitat at Ogden Bay Refuge, Weber County, Utah. Utah State Dept. F. & G. Publ. No. 6 of Fed. Aid Div., 87 pp.

This is a significant publication discussing the history, development, and ecology of this formerly barren salt flat that is now a major waterfowl refuge. All phases of waterfowl management are covered. (N.B. All the fine galaxy of waterfowl food and cover plants on the refuge established "naturally" when ecological conditions were altered to favor them. P.H.A.)

Nielsen, E. L. 1953. Revegetation of alkali flood plains adjoining the North Platte River, Garden County, Nebraska. Am. Midl. Nat. 49(3):915-919.

Edaphic climax on alkali flood plains are salt-tolerant grasses, Distichlis stricta and Spirobolus airoides. Soil alkalinity is high; phosphorus deficient. Formerly cultivated lands have slightly higher pH and less available phosphorus than virgin areas. Edaphic climax becomes established in 20-30 years.

Penfound, W. T. 1952. An outline for ecological life histories of herbaceous vascular hydrophytes. Ecology 33(1):123-128.

Presents a uniform method of wetland and aquatic plant categories to be used by students of these plants. Discusses various informational material in this field (plant identification, general, phenology, economic value, life history outline) and cites various authorities. Suggests this checklist for a life history outline: classification (nomenclature, description, ecological classification); distribution; habitat (climate, physiography, substratum); communities--general and specific; effect of habitat factors (water level, salinity, pollution, temperature, mowing, fire, plant parasites, animal predators and parasites); morphology and development (seed germination, seedling, vegetative body, vegetative reproduction, flowers, fruits, seed); economic value, economic harm; control methods (physical, chemical, biological). Contains 60 literature citations. This outline, promulgated in 1952, has been adopted for use by several authorities and provides a uniform method of approach for very complex studies.

Penfound, W. T. and E. S. Hathaway. 1938. Plant communities in the marshlands of southeastern Louisiana. Ecol. Mono. 8:1-56.

A detailed discussion of the composition, development, and phenology of plant communities of brackish, fresh, and salt water marshes near Lake Pontchartrain. Eleven plant communities are found: 3 forest, 4 zonal, 4 marshes. Edaphic factors discussed: salinities, water levels, water content and organic matter, salt tolerance. Phenology: six stages recognized; initiation of blooming for most species in vernal stage with a secondary peak in autumnal stage. Anthesis starts earlier in zonal communities than in true marsh associes. The greater the salinity of a marsh the later is the onset of anthesis for the majority of its species and the later is the maximum anthesis of the community. However, each individual species tends to bloom earlier in the more saline parts of its range.

Peterson, L. A., Jr. 1957. Vegetative change at a new reservoir in Nebraska 1951-56. USF&WS Mo. River Basin Stud., Billings, Mont., ii and 19 and 2 pp., 32 photographs, map, graph. Aug. 1957.

A new 30-mile shoreline revegetates to high value wildlife habitat as a result of fertile soil, favorable topography, fluctuation of water at suitable times, and exclusion of livestock.

Peterson, M. L., V. P. Osterli, and L. J. Berry. 1959. Managing irrigated pastures. Univ. Calif. Agr. Ext. Svc. Circ. 476, 31 pp.

General information for the wetlands manager interested in integrating waterfowl with cattle pasturing.

Purer, E. A. 1942. Plant ecology of the coastal salt marshlands of San Diego County, California. Ecol. Mono. 12(1):83-111.

This work concerns the distribution of salt marsh plants in their peculiar environment. The characteristics of the principal genera are noted. Salinity remains almost constant in and around large bodies of water and decreases at all stations in winter and early spring when rainfall depresses the surface saline concentration. There is a fluctuation in the soil salinity in the various plant communities and there is a general range within this fluctuation for each species. Aeration may play an important part, rather than maximum salinity or average total concentration, in determining plant zonation. The principal plant of the middle littoral zone is Salicornia, usually associated with two or more genera such as Distichlis, Suaeda, etc. The middle littoral zone is that area in which plants are bathed in tide water twice daily. Within this area, Scirpus is also found. Where fresh water seeps into the area, the zonation is different; Scirpus species are found, along with some of the salt marsh species which grow in less saline places. Tests show that deeper soil levels are progressively more saline.

Ranwell, D. S. 1961. Spartina salt marshes in southern England; effects of sheep grazing at the upper limits of Spartina marsh in Bridgewater Bay. J. Ecol. 49(2):325-340.

Five years of continuing experimental sheep grazing study on an English coastal salt marsh finds that a tall marsh vegetation of reeds and bulrush normally tends to replace saltmarsh cordgrass on upper limits where surface salinities are reducing due to land-drainage seepage. A normal rate

of change from Spartina dominant to Phragmites dominant is 8-10 years. Sheep grazing on the Spartina areas favors spread of Puccinellia sp. (a salt grass) and the tillering of Spartina, which in turn reduces ground space available for spread of the annual Atriplex hastata. Forage preference for sheep (entering new ground for first time) is: Aster, Puccinellia, Spartina, Atriplex. Sheep aid the spread of Puccinellia by treading fragments of this grass into soft mud; many of these fragments take root. This was particularly noticeable where a grazed and newly "planted" area would be irrigated by a succeeding high tide.

Rauzi, F. 1963. Water intake and plant composition as affected by differential grazing on rangelands. J. Soil & Water Cons. 18(3):114-116.

Regulated grazing can increase the amount of precipitation available for plant use. Investigation shows that loss of surface cover and heavy use by livestock decrease the rate of water intake. Total water intake on moderately grazed pasture was 1.6 times greater than on heavily grazed pasture; water intake on ungrazed area was 1.8 times as great as on moderately grazed area. There was also a marked difference in vegetative composition on the three areas studied.

Rhoades, E. D. 1967. Grass survival in flood pool areas. J. Soil & Water Cons. 22(1):19-21.

Inundation tolerance of 27 grasses was tested in Oklahoma. Early spring inundation during grass dormancy had little effect. Depth of flooding, as well as duration, had impact. Examples of inundation tolerance: very strong (over 20 days)--bermudagrass, knotgrass; strong (up to 20)--reed canary grass; moderately strong (up to 15)--western wheatgrass, rice cutgrass; moderate (up to 10)--Virginia wildrye, beaked panicum; mild (up to 5)--alkali sacaton, weeping love grass, smooth brome.

Robel, R. J. 1961. The effects of carp populations on the production of waterfowl food plants on a western waterfowl marsh. Trans. N. Am. Wildl. and Nat. Res. Conf. 26:147-259.

Studies on the Bear River marshes in 1959 indicated that turbidity in the water was not caused by carp but that carp did seriously affect the aquatic vegetation by eating and mechanically grubbing it out. When carp were stocked at less than 200 lbs./A. the effects progressively increased. The carp attained stocking levels as high as 2,000 lbs./A.

Robel, R. J. 1962. Changes in submersed vegetation following a change in water level. J. Wildl. Mgt. 26(2):221-224.

Changes in growth of submersed vegetation were measured after a 3" rise in the water level of a Utah marsh. Vegetative production samples, based on oven-dry weights, were taken 168 times per summer in 1959 and 1961. Production increased by 32% in shallow areas and decreased 35% in deeper areas. The marsh increased in size; duck food near nesting areas increased; and alkali bulrush grew more luxuriantly as a result of water level rises.

Robel, R. J. 1962. The relationship of carp to waterfowl food plants on a western marsh. Ph.D. Thesis, Utah State Univ., Diss. Abstr. 23(7):2282.

A three-year controlled experimental study on confined carp in 16 ponds is reported. Ponds had various confined populations: 200, 400, and 600 lbs./A. equivalents. Results: Carp did not, by their activity, cause turbidity. Water turbidity was correlated with sago pondweed growth. Pondweed abundance is directly proportional to carp populations. The author describes the carps' method of destroying aquatic vegetation as "undermining" or "undercutting" in contrast to the commonly used, but erroneous, terms of "rooting" or "digging."

Robinson, T. W. 1967. The effect of desert vegetation on the water supply of arid regions. Int'l. Conf. on Water for Peace, Vol. 3:622-630.

Discusses the "consumptive waste" of groundwater by phreatophytes in the arid regions of the Southwest. Clear and very simple definitions and categories are used. The uses of the few beneficial phreatophytes are cited; the water requirements and groundwater drafts by the non-beneficial phreatophytes are quoted from recent experiments and observations. The depleting effect on springs and streams by this groundwater draft is noted. Two techniques of water salvage to convert "consumptive waste" to "beneficial use" are: substituting plants of lesser water requirements for phreatophytes with greater requirements, or replacing low-value plants with those of higher economic value.

Salt, G. W. 1953. An ecologic analysis of three California avifaunas. Condor 55(5):258-273.

Cited in this bibliography not for the subject but as an example of a system of study that, regardless of taxonomic character, will permit the charting of faunal structures

with changes in environment due to seasonal change, plant succession, or land management. Provides a useful tool for an in-depth ecological study of any area.

Saugstad, S. 1939. Effect of artificial ponds on our duck populations. Bi-monthly Bull. (N. Dakota) 2(2):6-8.

Newly constructed stock ponds lack attraction for nesting waterfowl. Lack of suitable marginal vegetation appears the cause. The author believes that natural plant succession will remedy this, if grazing is controlled.

Schantz, H. L. 1938. Plants as soil indicators. USDA Yearbook "Soils and Men":835-860.

A clear, succinct summary covers the subject at an understandable technical level for the field management officer or biologist. Vegetation types are correlated with various soil series, ranging from forest types to tall and short grass prairie to desert and chaparral. A brief description of each type is given, plus many good photographs. The appendix lists: 1. plant communities as an indicator of growth conditions; and 2. vegetation types found on western raw lands. The grazing lands appendix lists carrying capacity of various vegetative types. Since this yearbook is normally found in most libraries--county, state, or agency--it will serve as a good ready reference.

Shanks, C. E. 1951. Fountain Grove Wildlife Area. Mo. Cons. 12(10):2-4. Oct. 1951.

On 3,433-acre tract in northern Missouri, 2,000 acres of shallow water and marsh have been developed since 1948. Management procedure: June drawdown exposes 1,500 acres of mudflat; wild millet and smartweed grow; marsh is reflooded in September. Half of the total area is a refuge, half is open to hunting.

Shearer, L. 1968. Palatability of duck foods after varying periods under water. Proc. 48th Ann. Conf. W. Assoc. F. & G. Comm.:294-299.

This study purported to test acceptability of 16 grains to approximately 50 mallards at Manito Park, Spokane. These ducks were conditioned to handfeeding by park patrons. The 16 grains were grouped in three classes: dry, soaked in water for 30 days, soaked for 60 days. Field corn was always first choice; others varied. Conclusions: The longer a grain is soaked the less the ducks like it.

Shearer, L., B. J. Jahn, and L. Lenz. 1968. Deterioration of duck foods when flooded. Proc. 48th Ann. Conf. W. Assoc. F. & G. Comm.:300-303.

Using techniques based on Neely (1956) the following results were obtained from 30-day deterioration tests.

Kind of Seed	S. Carolina	Washington
Soybeans	86%	84%
Jap. millet	57	49
Corn	50	37
Sorghum, grain	42 (Hegari var.)	39 (milo var.)
Sorghum, non-grain	23 (var. Drummonii)	27 (Sudangrass)
Millet	36 (Panicum ramosum)	34 (P. miliaceum)
Buckwheat	45 (common)	34 (Tartary b.)
Rice	19	31
Smartweed	21 (P. pennsylvanicum)	7 (P. lapathifolium)
Bulrush, saltmarsh	1	2

Shearer, L. A. 1960. Use of dugouts by breeding ducks. J. Wildl. Mgt. 24(2):213-215.

Following up the work on stock ponds in S. Dakota (Bue, 1952) and in Montana (Smith, 1953), in spring of 1958 the author studied 33 dugouts of various ages and habitat sites. Results paralleled Bue's and Smith's and stressed the importance of type of water area, and quality and quantity of nesting cover from dugout's edge to 100 yds. adjacent, as well as water level in the dugout itself. Conclusions: Ducks of several species use stock dugouts; good cover means more waterfowl use; full dugouts are used more than those with water 1 to 7 ft. below ground level.

Shearer, L. A. and H. G. Uhlig. 1965. The use of stockwater dugouts by ducks. J. Wildl. Mgt. 29(1):200-201.

Dugouts to store livestock water are usually dug with steep slopes on sides and slightly less steep ends. This design, functional for storage, provides poor resting sites for waterfowl. Scrap lumber rafts were placed on approximately one-half of 31 dugouts. Dugouts with rafts were more attractive to courting and breeding ducks.

Singleton, J. R. 1951. Production and utilization of waterfowl food plants on the east Texas Gulf Coast. J. Wildl. Mgt. 15(1):46-56.

Yields of seeds, stems, and leaves were determined for 14 waterfowl food plants. The average air-dried seed yield

for all species was 369.26 lbs./A. Stems and leaves, air-dried, averaged 10,766.4 lbs./A. Plant competition was found to be the limiting factor in seed production of beak-rush and wild millet. Burning in late winter retarded sawgrass and accelerated spring growth of smartweed. The account is factual concerning production in plants; information on utilization is inadequate.

Smeins, F. E. 1967. The wetland vegetation of the Red River Valley and drift prairie regions of Minnesota, North Dakota, and Manitoba. Ph.D. Thesis, Diss. Abstr. 28(10): 3963B.

This dissertation, a complex and intensive study, comprises a physical, chemical, and botanical analysis of 288 vegetation stands. For each stand, the species use and the dominant species are listed. Each stand is placed in one of four moisture classes, based on duration of standing water. Using indicator species, gradients are derived based on moisture, salinity, and disturbance, to which species behavior is plotted. Habitat types are defined by moisture regime (low prairie, high meadow, low meadow, emergent marsh, open marsh) and are described. Environmental fluctuations obscure the phytosociological structure of these wetlands, but the following is indicated: There is zonation and it is a result of many factors, particularly the moisture regime, the instability of environment, and the land use. Despite the vast size of the study area, the author found little differentiation of the wetland flora on a geographic basis. Similar conditions produce similar plant communities throughout the study area.

Smith, A. G. and H. R. Webster. 1955. Effects of hailstorms on waterfowl population in Alberta, Canada--1953. J. Wildl. Mgt. 19(3):368-374.

July hailstorms in 1953 in the parklands and on the prairies of Alberta killed 148,000 waterfowl, as well as other bird life. Damage to vegetation is described.

Smith, J. T. 1959. Local gun clubs encouraged to improve waterfowl habitat. Outdoor Calif. 20(8):14, 16.

This article is cited as an example that wetlands habitat for waterfowl can be improved rapidly, simply, and inexpensively--given cooperation between agencies and prompt, effective water supplies and controls. In the Grasslands (San Joaquin Valley, California) 120 acres of food-and-cover-poor and alkaline duck club lands, unleveled and unploughed, were flooded and drained to mudflat stage,

and then aerially sown to watergrass and black millet. Three flash irrigations brought the crop to maturity and produced a lush, attractive growth.

Smith, P. B. 1955. Waterfowl management on multiple-use reservoirs in Tennessee. Proc. 9th Ann. Conf. S. E. Assoc. G. & F. Comm.:223-226.

Comments during a showing of 56 photo-slides are given. Photos are not included in this publication.

Spinner, G. P. and J. S. Bishop. 1950. Chemical analysis of some wildlife foods in Connecticut. J. Wildl. Mgt. 14(2): 175-179.

The protein, fat, fiber, nitrogen-free extract, ash, and water content is given for over 100 wildlife food plants. About 30 of these are wetlands plants--aquatics, emergents, and non-emergents. For a small number of more common weeds, fall and winter comparisons are made. The authors recognize that the data are seasonally and geographically restricted. They suggest that to pinpoint the answers would be so difficult technically, and so expensive, that only if faced with highly intensive management objectives could the cost be justified.

Stevenson, R. E. and K. O. Emery. 1958. Marshlands at Newport Bay, California. Allan Hancock Found. Publ., Occas. Papers No. 20, 1-109.

Although this paper discusses the physiography, water characteristics, sediments, and flora of a coastal salt marsh, the data have wide application to any saline or inland alkaline marsh. Data for salinity and germination rates and on the floating capacity of seeds are given for Triglochin, Typha, Suaeda, and Salicornia. Most genera were tolerant of 1-2% NaCl, but a decrease in salinity of the surface layers of soil is a necessary prerequisite for germination in early spring. The physical qualities of soil are probably important only as they bear on factors such as aeration (drainage) and salinity. A determining factor is the period of exposure to air since, regardless of any other condition, air does not have access to the soil during submergence. Because of the epidermal characteristics of most marsh plants, little interchange of gases takes place between the plants and the water.

Thorne, J. P. and D. W. Thorne. 1951. Irrigation waters of Utah. Utah State Agr. Coll., Agr. Expt. Sta. Bull. 346, 64 pp.

Most of the irrigation streams in Utah were sampled in 1949 and 1950, and chemically analyzed. The analyses are interpreted, not only chemically, but also in terms of soil and farm practices. The various state drainages are described briefly and the salt tolerances of some common plants are given.

Tryon, C. A., Jr. 1954. The effect of carp exclosures on growth of submerged aquatic vegetation in Pymatuning Lake, Pennsylvania. J. Wildl. Mgt. 18(2):251-254.

In Pymatuning Lake, 1/100-acre fenced and unfenced quadrats were studied for three years. Average annual growth of submerged aquatics was 3.9 gr/sq. m (air dried vegetation) in fenced quadrats and 1.4 gr/sq.m in unfenced quadrats. Differences in plant growth were attributed to rooting and splashing of carp. Turbidity, while a factor, appears not responsible for differences between fenced and unfenced quadrats.

Uhler, F. M. 1944. Control of undesirable plants in waterfowl habitats. Trans. 9th N. Am. Wildl. Conf.:295-303.

An early but still informative paper lists "undesirable" and "useful" plants and describes the control measures then known: water level manipulation, chemical, mechanical, manual, and biological. All save chemical controls are in 1969 about as they were in 1944.

Uhler, F. M. 1955. Waterfowl management in unfavorable sites. Proc. N. E. Sect. Wildl. Soc. et al. Mar. 1955, 5 pp.

This resume of management practices that have worked at Patuxent Research Refuge in Maryland, on the Atlantic seaboard, in an area of acid-water marshes, discusses seasonal drawdowns, food plants for mud flats, turbidity, acid-water tolerant food plants, nesting and loafing islands, predator control, and water control structures.

Uhler, F. M. 1956. New habitats for waterfowl. Trans. 21st N. Am. Wildl. Conf.:453-469.

Developments over several years on Patuxent Research Refuge in Maryland are described. Although the acidic waters of the Atlantic seaboard, the climate, and the soils present vastly different problems than those facing the western

wetlands manager, the accounts of sewage effluent use and manipulation, and the use of abandoned gravel pits for waterfowl, are of value.

Uhlig, H. G. 1963. Use of Minnesota ponds and pits by waterfowl. Wilson Bull. 75(1):78-82.

Observations on stock-water pits (dugouts) and farm ponds in Minnesota during 1957-1960 find that ponds (av. size 1 acre, 12 ft. deep) are more heavily used than pits (av. size ¾ acre, 10 ft. deep). Stable-level ponds and pits have more use. Irregular and shallow shorelines of pond favor waterfowl. But good vegetative cover on shoreline is the most important factor determining degree of use in pits and ponds. These small water areas are used during migration as well as for courting, breeding, and brood rearing. Trials indicate pits may be more attractive if loafing sites (anchored rafts, at least 4x4 ft.) are installed for waterfowl.

Ungar, I. A. 1966. Salinity tolerance of marsh plants in Kansas and Oklahoma. Ecology 47(1):154-158.

Five hundred soil samples and plant records for 21 species of marsh plants were correlated for salt tolerance indications. Conclusion: A wide range of salt tolerance was found for these halophytes--none of the plants is an obligate halophyte. The author suggests that so-called "obligate halophytes" live in saline sites since they can not compete with more vigorous but less tolerant species in less saline sites. In 21 test plant species salinity concentrations in surface soils (0-10 cm) were extremely important for the establishment of species growing on salt flats. All these plants must germinate at soil surface and the roots of many pioneer invaders were concentrated at this level. All but the most salt-tolerant species were eliminated by the high salt concentrations and osmotic pressures in these surface soils. The subsurface soils usually had lower salinities than the surface soils. This paper points up two major principles of habitat manipulation in the management of wetlands of the western U. S.

Vogl, R. J. 1964. The effects of fire on a muskeg in northern Wisconsin. J. Wildl. Mgt. 28(2):317-329.

Controlled burning of muskeg is analyzed quantitatively on 14 paired stands; vegetation is sampled. Burning converts conifer swamp to open sphagnum bog or muskeg. Muskeg, when burned, converts to sedge meadow--best game bird habitat.

Vogl, R. J. 1966. Salt marsh vegetation of Upper Newport Bay, California. Ecology 47(1):80-87.

Littoral and maritime zones were sampled for frequency and occurrence of cover. Nine species, principally Gramineae and Chenopodiaceae, dominated the marsh. Salicornia virginica accounted for the highest total average frequency and cover. Plant communities were simplest in low areas (4 species) and graded to more complex in the higher areas (15 species). Individual species could not be separated into zones, since the frequency of occurrence along environmental gradients produced a vegetational continuum.

Weller, M. W., B. H. Wingfield, and J. B. Low. 1958. Effects of habitat deterioration on bird populations of a small Utah marsh. Condor 60(4):220-226.

Compares bird populations on the same area in 1950 (a wet year) and 1955 (at the end of a 3-year drought).

	1950	1955
Vegetation	lush marshy	scant, overgrazed
Duck nests	6.6 per A.	2.6 per A.
Colonies of wading birds	present	all gone, save great blue heron (92% down)
Gadwall	present	increased (dry land nester)
Pied-billed grebe	present	absent
Western grebe	present	absent
Ruddy duck	present	absent

Wolf, K. 1955. Some effects of fluctuating and falling water levels on waterfowl production. J. Wildl. Mgt. 19(1):13-23.

A nine-month study on a M.S. thesis. Direct damage to eggs by water was caused by partial or complete submersion. Both mallards and redheads attempted to save their clutches by building nests higher. This only resulted in unstable nests and egg loss by spilling. Flooding caused a loss of 31% of the potential waterfowl production; damage to mallard nests was more severe than to other species observed. Brood survival did not differ in areas of stable, falling, or fluctuating water levels.

Yarlett, L. L. and J. R. Moore. 1963. Management of Gulf Coast salt marshes. J. Soil and Water Cons. 18(4):166-167.

Salt marshes of the Gulf Coast of Florida have average annual rainfall of 50 inches; 60% of this in summer. The climate is subtropical. These salt marshes have excellent

potential for grazing and wildlife use. Seven marsh soils are described: four mineral soils, organic peat, floating or boggy peat, and hammock site. Hammocks are limestone rock "islands" in coastal peat marshes. Black needlerush, Juncus roemerianus, is the pest plant to control. Cordgrasses and saltgrass are valuable pasture forage. Widgeongrass is common waterfowl food; water and salinity controls are essential for production.

Yeager, L. E. and H. M. Swope. 1956. Waterfowl production during wet and dry years in north-central Colorado. J. Wildl. Mgt. 20(4):442-446.

Waterfowl production in 24 small marshes, ponds, lakes, and stream sections was studied during wet year (1949) and drought (1955). On these, habitat was reduced 61.8% and production 75% in drought. However, losses for the general area were partially compensated by increased river bottom and farmland production (flooded out in 1949) and general area decline in drought was only 44.4% in waterfowl production.

SECTION C

WETLANDS TECHNOLOGY AND EQUIPMENT

Section C, 72 citations, contains specific and factual "how-to" information. A smattering of referrals to waterfowl handling, banding, or marking is included to assist the wetlands manager who will, sooner or later, find himself involved in a waterfowl field research project.

Arend, P. H. 1960. "Photomapas"--apparatus and techniques used in a marsh vegetation survey. Calif. Dept. F. & G. P-R Proj. W-30-R. 2 pp. Mimeo. 1 fig.

Describes an inexpensive do-it-yourself color photograph mapping apparatus devised for transferring the images of 35 mm aerial color snapshots to a scaled outline map, in order to derive acreage and species composition percentages for a vegetation survey of the 42,000-acre Suisun Marsh. Difficult access prevented the use of customary range survey methods. The accuracy of the photographic coding data was checked against random samples of field survey data and an adequate correlation was found. Once the color photos are obtained the survey findings can be duplicated or rechecked by another observer without loss of accuracy or time. Cost of materials for the "Photomapas" (photo mapping assembly)--excluding the slide projector--was under $35.00 in 1960.

Arend, P. H. 1969. Explosives in marsh management. Trans. 16th Ann. Conf. Calif.-Nev. Sec. Wildl. Soc. (in publication).

Blasting marshland ditches and potholes with propagating dynamite (Farmex) and nitro-carbo-nitrate is described step-by-step, with emphasis on safety and efficiency. A refinement in the techniques of fusing NCN, to prevent underwater misfires, is presented.

ARMCO. 1936. Handbook of water control. ARMCO Drainage & Metal Products, Inc., 573 pp.

A standard reference. A revised edition exists but was not reviewed. Covers it all--from dams and penstocks to sprinkler valves.

ARMCO. 1945. Handbook of culvert and drainage practice. ARMCO Drainage & Metal Products, Inc., 473 pp., supplements and tables.

A technical manual covering drainage history, strength of materials, soil/water chemistry affecting durability of materials, hydrology and hydraulic capacities, various drainage types, field installation instructions, etc.

Atlas Powder Co. 1953. Ditching and water control with explosives. Atlas Powder Co. Leafl. ATL 276, 14 pp.

The basics of using propagating ditching dynamite are given. Farmex Ditching Dynamite, a 50% straight nitro-glycerine explosive, is made for this purpose since it is strong,

sensitive, quick-acting. Only one charge in a string is fused; this explosion sets off a string of charges by a shockwave carried from one exploding charge to the next--hence "propagating." Suggested loadings for width and depth of ditches are tabulated. Recommended designs for various jobs are offered, along with safety precautions.

Atlas Powder Co. 1957. Atlas explosive products, Catalogue No. 13. Atlas Powder Co., Wilmington, Del., 48 pp.

A trade brochure that presents explosives information for strip mining, quarrying, construction, mining, seismic prospecting, pipe lining, agriculture, and lumbering, and cites other uses of explosives. This section is followed by a catalogue of Atlas high explosives and blasting agents, fuses, caps, wire, detonators, and other accessories. Indexed. No prices quoted.

Balham, R. W. and W. H. Elder. 1953. Colored leg bands for waterfowl. J. Wildl. Mgt. 17(4):446-449.

Describes materials and techniques of banding with colored, heated plexiglas strips "formed" to bird's leg with banding tongs.

Brown, L. N. 1953. Small earth dams. Univ. Calif. Agr. Ext. Svc. Circ. 467, 23 pp.

This circular discusses privately owned small earth dams, the laws involved, selection of a site, construction details; maintenance practices for the dam, spillway, reservoir, and watershed; and management for both practical and recreational uses of the reservoir.

Brown, L. N. 1954. Contour planting and irrigating on moderate-to-steep slopes. Univ. Calif. Agr. Ext. Svc. Circ. 440, 23 pp.

This pamphlet sketches the principles of contour irrigation and presents layouts of contour plantings designed for small acreages. Specialized terminology is simply defined, and the pamphlet offers a number of technical tips on methods, viz. use of grade boards, contour surveying, contour irrigation ditching, etc., that can find field application in wetlands management.

Bumstead, A. R. 1954. Game management on a flood control reservoir. Miss. Game and Fish. 18(5):3-5.

Terraces, two feet high, are built along contours on perimeter of reservoir. During summer drawdown these terraces

impound shallow strips of water to furnish seed beds for millets and smartweeds. No borrow pits or control structures are built in these simple and inexpensive dikes.

Canada Department of Agriculture. 1963. Machines for marshland ditching. Can. Dept. Agr. Bull. 1195, 14 pp.

Nine machines, experimentally tested for marsh ditchwork, are described and illustrated. Five machines are for field ditches; the other four for main channels. Some of the machines will operate from a conventional farm tractor, but most require a special gear-box to reduce forward speed to 1,200 ft./hr. at full governed speed. Machines tested: Bahrs--auger-type rotor; Melio--auger-type rotor, tractor straddles ditch; Newage--side mount 8-blade hydraulic rotor; Ridder--back-mount, cutter wheel; Ritscher--back mount, auger type. The next 4 are ditch cleaners: Golddigger--impeller with 2 horizontal gathering augers, winches own way through ditch; Grabenfrei--similar to above except motive power is winch from PTO on tractor; McConnel--back-hoe type; York--small dredge on pontoons, auger-type gear serves as cutter and suction pump.

Cartwright, B. W. 1942. Regulated burning as a marsh management technique. Trans. 7th N. Am. Wildl. Conf.:257-263.

Canadian hay ranchers were persuaded to cooperate in controlled burns of prairie pothole area before April 20, prior to onset of duck nesting. Hay cutting was delayed until July 20, after peak of nesting.

Conway, R. C. 1938. Marsh burning. Wisc. Cons. Bull. 3(7):9-10.

For good marsh management burn should be light, destroy very little food and cover, and controlled to intended area.

Cook, A. H. 1957. Control of muskrat burrow damage in earthen dikes. New York F. & G. J. 4(2):213-218.

To control muskrat damage to earthen dikes metal wire barriers, asbestos sheeting, chemical control with calcium carbide, and bermed dike construction were tried. Real success came only from asbestos sheeting barriers dug vertically into the dike crown, and from berms (level extension of the normal dike into the impounded area). No correlation was found between the location of food supply and muskrat burrows. Heavy clay soil was less subject to burrowing than peat or loam. The muskrats don't mind swimming to lunch but they dig where the labor is easy.

Davison, V. E. 1955. Managing farm fishponds for bass and bluegills. USDA Farm Bull. 2094, 17 pp.

The information is primarily directed to areas in southern United States. Site selection, pond construction, controlling erosion and runoff, stocking, fertilizing, waterweed control, fishing, trouble and treatments are discussed.

Davison, V. E., J. M. Lawrence, and L. V. Compton. 1962. Waterweed control on farms and ranches. USDA Farm Bull. 2181, 22 pp.

Prevention and control of waterweeds, particularly in the southeastern United States, is discussed. Mechanical controls in fish ponds, irrigation reservoirs, and ditches are suggested. The types of waterweeds (submersed, marsh, rooted floating-leaved, floating, algae, shrubs and trees) are defined. Waterweed control by mineral fertilization is detailed. Control results from darkening and shading of the acidic waters of this region. A list of standard chemical herbicides and application methods is also presented.

Dobie, J. and R. E. Johnson. 1951. Pond mapping by aerial photographs. J. Wildl. Mgt. 15(2):221-222.

Brief article shows how to get a scaled aerial photo by stake-marking a known distance on the ground and taking a low-level aerial photograph.

Domenick, D. and D. Hopper. 1968. Potholes for waterfowl. Colo. Outdoors 17(2):18-19.

This photostory depicts pothole blasting with ammonium nitrate. Charges of 25, 50, 70, and 150 lbs. produce four different-sized potholes--ranging from 6 to 8 feet deep and from 15 to 40 feet in diameter. Cost of materials for blasting a 15-foot diameter pothole was approximately $5.00. Electric caps and dynamite are used to detonate plastic-bagged explosive.

E. I. du Pont de Nemours & Co. (Inc.). 1958. Blasters' handbook. 14th Ed. Wilmington, Del., 516 pp.

A manual describing explosives and practical methods of using them.

Evans, C. D. 1951. A method of colormarking young waterfowl. J. Wildl. Mgt. 15(1):101-103.

A description of the techniques used to inject food dyes into incubating eggs. 70% of embryos survived injection. Colors lasted up to four weeks in ducklings. Recommended injection period is one week prior to hatch.

Finfrock, D. C., F. C. Raney, M. D. Miller, and L. J. Booher. 1960. Water management in rice production. Univ. Calif. Agr. Ext. Svc. Leafl. 131.

This map-fold leaflet is packed with illustrated information on land-grading, diking, water facts (sources, requirements, temperature, quality), water management (flooding, depth control, removal for harvest), distribution (delivery, drainage, mosquito control, canal gates, levee boxes, depth stakes), and tips on alkali levees, animal pests, etc.

Geib, J. R. 1956. Cannon for Canadas. Colo. Outdoors 5(6): 22-23.

Four brief paragraphs and six photos with captions give a resume of Colorado's cannon-netting technique. A 5-pound projectile is fired by a 12-gauge shotgun shell reloaded with 180 gr. black powder primed with electric squib. Net is 75' x 40'; discharge of cannons is controlled by radio.

Grizzell, R. A., Jr. 1960. Water impoundments--their design and management for fish, wildlife, and recreational uses. 25th Ann. Mtg. Am. Soc. Agric. Eng., Ga. Sec., 8 pp. Abstr. WR 103:14.

From abstract: "Agricultural water impoundments provide essential habitat for fish, shrimp, crayfish, waterfowl, and other species of aquatic wildlife. The proper design of the dam is the key to many techniques involving water management. The techniques include the following: deepening the shoreline of fish ponds; designing the proper spillway; creating diversions and terrace systems; using drawdown slots or gates; and taking the overflow from bottom waters."

Guardian Chemical Corporation. 1968. Polycomplex* A, microdispersant and solubilizer for heavy crude or fuel oils in sea water. (*Trade Mark). Guardian Chem. Corp., Chem. Div., Long Island City, N. Y., 11 pp and supplement.

This trade brochure describes the chemical used to clean the oil-soaked water birds contaminated by the Santa Barbara (Calif.) oil leak catastrophe of 1969. As reported

by field workers, Polycomplex* A removes the oil from bird feathers with no damage to the bird, its feathers, or the workers' hands. The chemical also breaks up oil spills and helps to disperse them to a harmless form.

Hammond, M. C. and G. E. Mann. 1956. Waterfowl nesting islands. J. Wildl. Mgt. 20(4):345-352.

Data are derived from 70 small islands constructed in 1935 on Lower Souris Refuge in North Dakota and from general observation elsewhere in the Northwest by the senior author. Costs (1955) and construction details are given. Conclusions: Nesting islands are valuable production sites for Canada geese and some ducks; edge effect is important. Recommendations: smaller rather than larger islands; isolate islands from mainland in open water at least 12 inches deep; control island edge erosion.

Hanson, H. C. 1950. Methods of determining age in Canada geese and other waterfowl. J. Wildl. Mgt. 13(2):177-183.

In this early account of a now-standard technique, the author discusses cloacal examination of geese and suggests use of speculum to assist in examination.

Harris, S. W. 1953. A throw net for capturing female waterfowl on the nest. J. Wildl. Mgt. 16(4):515.

The throw net frame, made of flexible conduit, was a 5 ft. by 6 ft. ellipse, bolted for folding. The netting was a loose 1-3/4" mesh. The net could be thrown by hand "with accuracy up to 35 feet" and was used to trap three females on their nests.

Hay, K. 1958. Inside the Outdoors (column): "Evaporation Retardation." Colo. Outdoors 7(1):15.

One paragraph notes the work by U. S. Bureau of Reclamation and Colorado State University, where in experiments with monomolecular film of Cetyl alcohol (6 ten-millionths of an inch thick) water evaporation has been reduced by 45% to 60%. Tests on ecological impact were stated to be underway, but I found no further report.

Hazeltine, B. M. and V. Ekdahl. 1945. "Paul Bunyan" rake for removal of marginal vegetation in botulism control. J. Wildl. Mgt. 9(3):193-195.

To combat severe weed conditions on Montana refuges, a "raft-dozer" to beach vegetation, and a giant rake to haul

in decayed pondweed above water-line were designed, built, and used successfully.

Hunt, G. S. and K. J. Dahlka. 1953. Live trapping of diving ducks. J. Wildl. Mgt. 17(1):92-95.

Describes construction of lily-pad shaped weldwire fence and chicken wire trap for diving ducks. A unique feature is the top escape hatch for ducks in the event of high water.

Institute of the Makers of Explosives. 1955. Explosives in agriculture. (5th printing, rev.) Inst. Makers of Expl. New York 17, N. Y., 78 pp.

Details the properties and many uses of explosives in agriculture. Safety fuses, blasting caps, method of series connections, priming and priming tools, fire fuses, and electric caps are diagramed and discussed. Transportation, storage, and misfires are covered. Stumping, ditching (including wide-ditching and ponding), rock and boulder blasting, and other farm uses such as tree planting, drainage, excavations, ice blasting, etc., are detailed thoroughly.

Jepson, H. G. 1944. Prevention and control of gullies. USDA Farm Bull. No. 1813, 59 pp.

Wetlands managers will find information in the section "Structures" (p. 33-41) on check dams, woven-wire dams, brush dams, loose-rock dams, and plank or slab dams, useful as temporary or inexpensive water controls. Permanent concrete masonry and earth dams are also discussed (p. 41-49).

Johnston, C. N. 1952. Irrigation pumps; their selection and use. Univ. Calif. Agr. Ext. Svc. Circ. 415, 54 pp.

Centrifugal, turbine, screw-types, and combination or mixed-flow pumps are illustrated and their operating characteristics discussed. The elementary technical terminology of wells and pumps is presented clearly and concisely. Costs, installation methods, and maintenance are discussed. To some degree, every wetlands technician must become familiar with the kind of information presented in this circular.

Kozlik, F. M., A. W. Miller, and W. C. Rienecker. 1959. Color marking white geese for determining migration routes. Calif. Fish and Game 45(2):69-82.

The writers describe techniques and materials used to dye Ross and snow geese, in vivo. Results are summarized:

Picric acid (yellow) dye lasts longest; others--malachite (green) and rhodamine B (pink)--are less durable.

Lauritzen, C. W. 1967. Butyl--for the collection, storage and conveyance of water. Utah State Univ. (Logan, Utah) Agr. Expt. Sta. Bull. 455, 41 pp.

Describes the use of Butyl sheeting as a water barrier. Although Polyethylene and Vinyl are good membranes when covered with earth, Butyl is more durable for exposed areas. Various tests and experiments are detailed and methods of use are outlined.

Lauritzen, C. W., F. W. Haws, and A. S. Humphreys. 1956. Plastic film for controlling seepage losses in farm reservoirs. Utah State Agr. Coll. Agr. Expt. Sta. Bull. 391, 18 pp.

Polyethylene (PE), Vinyl, and other plastic films were tested to determine resistance to weathering, rot, exposure, root and sprout penetration, rupture, and mechanical damage. PE generally rated best. Vinyl deteriorated rapidly in direct sunlight.

Linde, A. 1960. Portable pump useful in conservation. Wisc. Cons. Bull. 25(7):29-32.

A home-made portable pump is built around a 1949 Johnson 10 hp. outboard motor. Major additional parts are two short 6" diameter steel tubes that make up the pump housing, a home-made 3-blade impeller to replace outboard propeller, and flexible hose lines. The conventional outboard can be converted to pump and back to outboard in minutes. Weight of motor and conversion parts is 70 lbs. The pump was designed to pump water, trash, and muck from marsh ditches; but it will serve as a portable, high-capacity, low lift water pump discharging 1,000 - 1,500 gpm. "Construction details can be obtained by writing to author at Box D, Horicon, Wisconsin."

Linduska, J. 1960. Fire for bigger game crop. Sports Afield 143(1):30-31, 88-90.

This semi-popular article tells of "cold" burning in spring, on Lake Erie duck marsh, to produce millet, etc.; of fall burning on Gulf Coast to remove sawgrass and expose the seed for goose forage; of marsh brush control with fire in the Southeast; and of burning as an upland game management tool. Emphasis is on controlled, timely use of fire as a tool.

Lynch, J. L. 1941. The place of burning in management of Gulf Coast wildlife refuges. J. Wildl. Mgt. 5(4):454-457.

Burning is a practical tool in marsh management for cattle, fur, and waterfowl. Marsh fires are classed as cover, root, and deep peat burns. Function of fire is to: improve food and cover, make more food available, control wildfires, make fur-trapping easier.

Mann, G. E. 1964. Improved techniques for aerial wetland surveys. J. Wildl. Mgt. 28(3):575-580.

Techniques used in an intensive aerial wetland survey of more than 13,000 square miles of western Minnesota pothole range are reported. Using light aircraft and experienced pilots, two men were able to cover the entire area in two seasons. Coverage of all sections in a township by the one-mile wide inspection method took 20-25 minutes. The technique proved to be an economical, rapid, and accurate way to locate and establish acquisition priorities.

Marr, J. C. 1957. Grading land for surface irrigation. Univ. Calif. Agr. Ext. Svc. Circ. 438, 55 pp.

This technical manual details site selection, surveying, three methods of grade calculation (least-squares and average profiles, cross-section, two-way profile), cut and fill estimates, etc. Grading equipment such as crawler and two- or four-wheeled tractors, rotary scrapers, bottomless scrapers, chisels and rippers, are illustrated and discussed. Suggestions for grading contracts and specifications are advanced. An appendix gives details of methods of land-grading calculations with tables and graphs.

Marr, J. C. 1958. The border method of irrigation. Univ. Calif. Agr. Ext. Svc. Circ. 408, 24 pp.

This pamphlet is a primer of irrigation practices. Equipment and methods are illustrated by good photos, diagrams, and clear writing. Machinery is shown and discussed briefly: a border disk, ridger, ditcher, scrapers of several kinds, shaper, a strip check drag, and others. Levee or dike designs are given, as well as cost estimates. Water control structures are illustrated and discussed, including alfalfa valves and distributing heads, wooden check gates, canvas check dams, flume border gates, portable ditch siphons, etc. A table showing simple calculations for water application is on the last page.

Mathisen, J., J. Byelich, and R. Radtke. 1964. The use of ammonium nitrate for marsh blasting. Trans. 29th N. Am. Wildl. Conf.:143-150.

The use of an ammonium nitrate/fuel oil mixture (AN/FO) as a blasting agent for cratering charges and potholes in marsh management is described. The FO serves as a carbonaceous carrier for the prilled AN. A dynamite primer is required for detonation. A major problem in marsh work is to keep the AN/FO dry (see Arend, 1969). Strong waterproof polyethylene bags are used for packaging the charges, but the inserted primer may leak around wires to cause a misfire. A cost analysis (1964) is given. AN/FO materials generally cost about half as much as dynamite.

Murdock, S. H. 1966. A pond or a puddle. J. Soil & Water Cons. 21(5):180-182.

Based on work in limestone and glacial till areas of Indiana, this paper on how to plug a leaky farm pond has general application. Discusses site selections, chemical dispersants such as salt (NaCl) and soda ash ($Na_2 Co_3$). The use of high-swell clays (Bentonite) as sealants or fillers for permeable or sandy soils is discussed. Various treatments are outlined. Author estimates average cost (1966) of sealing a pond at $300 per surface acre.

Nelson, N. F. and R. H. Dietz. 1966. Cattail control methods in Utah. Utah State Dept. F. & G. Publ. No. 66-2, 31 pp.

The various control methods were grouped into five types: mechanical (hand cutting, rotary cutting, side cut mowing, crushing, cultivation), chemical, explosives (dynamite, terytol, ammonium nitrate), fire, and drought. Effectiveness of each control method was judged by total cattail kill, invasion of beneficial food plants, and increase of use by waterfowl and hunters.

Petrides, G. A. 1947. A new marsh vehicle. J. Wildl. Mgt. 11(4):352.

The Army "water weasel" is an amphibious vehicle for travel over swamps and boggy areas, and has a top ground speed of 30 mph over good terrain and 6-8 mph over open water. It appeared that this vehicle had high potential for marsh management work. (However, field experiences with the weasel, after this paper was published, have been generally dismal. The initial high cost, frequent breakdowns, and expensive maintenance of war surplus vehicles have discouraged most people who have tried the weasels. P.H.A.)

Provost, M. W. 1948. Marsh-blasting as a wildlife management technique. J. Wildl. Mgt. 12(4):350-387.

Reviewing 1940-41 marsh blasting project in Iowa, the author finds that potholes blasted in deep water produced emergent vegetation of higher value than those blasted in shallow-water sedge marsh. Blasting should be used only when water level controls are impracticable.

Schmid, W. D. 1965. Distribution of aquatic vegetation as measured by line intercept with SCUBA. Ecology 46(6):816-823.

Aquatic vegetation in a lake was measured by means of line transects run underwater with SCUBA. Transects were run along depth contours at ½ meter depth and at 1 meter intervals, down to 11 meters. Each transect was 20 meters long and plant species were recorded at intervals of 1/3 m. Some inter-species correlations were observed and these appeared to be related to water depth and the texture of the substrate.

Scott, J. H. 1956. Sprinkler irrigation. Univ. Calif. Agr. Ext. Svc. Circ. 456, 44 pp.

The uses, advantages, limitations, and costs of sprinkler irrigation systems are discussed. Systems are classified into: portable, semi-portable, and stationary. Distributing systems, i.e. rotating sprinklers, fixed heads, nozzle lines, or perforated pipelines, are illustrated and discussed. Accessory machinery, couplings, valves, pumps, etc., are noted. Design and operation are discussed.

Scott, T. G. and W. L. Dever. 1940. Blasting to improve wildlife environment in marshes. J. Wildl. Mgt. 4(4):373-374.

Describes early use of propagating dynamite in ditching and pot-holing marshlands. Shots resting on hardpan turned out good; those on deep muck were worthless.

Scott, V. H. and C. E. Houston. 1959. Measuring irrigation water. Univ. Calif. Agr. Ext. Svc. Circ. 473, 52 pp.

This useful reference defines and describes a rectangular contracted weir, V-notch weir, Cipoletti weir, rectangular suppressed weir, and Parshall measuring flume, as well as simpler devices for measuring flowing water.

Sheldon, M. G. 1957. A new nest for honkers. Colo. Outdoors 6(6):25-26.

Five photos and one paragraph on honker nesting platform; built of 2 x 6 members, elevated with metal pipe legs, and decked with hay bales.

Shen, R. T. 1959. Sealing sandy ditches with the Bentonite dispersion method. Univ. Wyoming Agr. Ext. Svc. Circ. 158, 9 pp.

Simple, illustrated manual showing use of Bentonite, a sealing clay. Approximate costs are given. (This and the following circulars by R. T. Shen should be part of any marsh manager's personal library.)

Shen, R. T. 1959. Sealing rocky ditches with the Bentonite multiple-dam method. Univ. Wyoming, Agr. Ext. Svc., Circ. 159, 9 pp.

Illustrated manual showing use of Bentonite and bridging materials (sawdust, silt, coarse clay) to seal rocky channels. Cost estimates are given.

Shen, R. T. 1959. Mixing Bentonite for sealing purposes. Univ. Wyoming Agr. Ext. Svc., Circ. 160, 9 pp.

Describes machinery (hoppers and dispensers) used for handling Bentonite sealing mixtures.

Shen, R. T. 1959. Testing Bentonite for sealing purposes. Univ. Wyoming Agr. Ext. Svc., Circ. 161, 9 pp.

Illustrated manual describes Bentonite, a sealing clay, tells its uses, and details simple field tests to determine whether "high swell" or "low swell" material is best for a specific job.

Shen, R. T. 1959. Sealing farm ponds and reservoirs with Bentonite. Univ. Wyoming Agr. Ext. Svc., Circ. 162, 9 pp.

Illustrated manual describes various techniques (mixed blanket, pure blanket, slurry, sprinkle, grouting, trenching) of preventing or plugging leaks in ponds or reservoirs by the use of Bentonite.

Siegler, R. H. 1941. A water plant census technique. J. Wildl. Mgt. 5(4):423-426.

The field technique presented, using measured paces and a tally recorder, is simple and is more accurate than

"guesstimating," but not nearly as accurate as present-day aerial photography and mechanical recording with computer analysis.

Sincock, J. L. 1962. Estimating consumption of food by wintering waterfowl populations. Proc. 16th Ann. Conf. S. E. Assoc. G. & F. Comm.:217-221.

Written in impenetrable biologese, the primary point made in this paper is that a waterfowl eats daily, in dry weight of waterfowl foods, an amount estimated to be equivalent to 10% of the bird's wet body weight. If you happen to know how much dry-weight of duck food you have on an area and how much your waterfowl population weighs wet, you can calculate how long the rations on your marsh will last, give or take a few variables. For example, during 1958-61, waterfowl on Back Bay (Va.) and Currituck Sound (N.C.) averaged 21,591,850 wintering waterfowl days, to consume an average of 11,631,323 lbs. of food per winter.

Sincock, J. L. and J. A. Powell. 1957. An ecological study of waterfowl areas in central Florida. Trans. 22nd N. Am. Wildl. Conf.:220-236.

Although written with the lucidity so characteristic of many biologists, this is a valuable paper since it presents the materials and techniques used in a large-scale, point transect vegetation survey in marshlands. A four-man crew followed 6" contours surveyed around the lakes' edges. Plant species frequencies were checked with a special point sampling device. IBM Mark Sense cards were used to record the data. The local ecological information derived from this Florida study will have little value to western wetlands ecologists.

Strohmeyer, D. L. and L. H. Fredrickson. 1967. An evaluation of dynamited potholes in northwest Iowa. J. Wildl. Mgt. 31(3):525-532.

Twenty-one potholes blown in 1940-41 were studied in 1962-65. After 21-22 years the potholes had lost 71% of their original blown depth; 1962 depth was nearly uniform regardless of original blown depth. Potholes appear to have continuing ecological value to marsh birds, although natural openings are more useful, except in drought years when vegetation over the balance of the marsh is dense. Authors suggest that low-level dams may, in some areas, be cheaper and more effective than dynamited potholes.

Sypulski, S. L. 1943. The Seney bulrush picker. J. Wildl. Mgt. 7(2):230-231.

Description and illustration of a seed-gathering implement designed like a blueberry rake.

Turner, L. B. 1953. A rapid method of sexing Canada geese. J. Wildl. Mgt. 17(4):542-543.

Claiming that cloacal examination is not only difficult and laborious but possibly damaging to geese genitalia, the author describes two other sexual differences useful in field examination: the wedge-shaped head profile of the male and the enlarged wrist callosity or knob of the adult male. (N.B. These may be useful distinguishing characteristics, but a skillful, strong-handed technique of cloacal examination will neither damage the waterfowl nor overtire the examiner. P.H.A.)

U. S. Army. 1954. Explosives and demolitions. U. S. Dept. of the Army Field Manual 5-25, Sept. 1954.

Designed primarily for combat demolition training, this manual contains clear, careful instructions on methods that can be applied to wildlife management.

U. S. Army. 1960. Map reading. U. S. Dept. of the Army Field Manual 21-26, Oct. 1960.

A technical guide with valuable basic information for the wildlife management officer or biologist. The chapters on field sketching and mapping of terrain, and on aerial photography, are particularly recommended for study.

USDI. 1964. Water development--range improvements in Nevada for wildlife, livestock, and human use. USDI Bur. Land Mgt., Reno, Nev., 37 pp.

Publication presents plans, specifications, and a resume of a dozen different types of wildlife water developments installed on BLM lands in Nevada. These include reservoirs, spring developments, trough float boards, bird ladders, water spread system, "charco" (dugout), bird and game water catchments ("guzzlers"), and reinforced concrete dams.

USF&WS. 1949. Propagation of wild duck food. USF&WS, Branch Wildl. Ref., Wildl. Mgt. Ser. Leaflet No. 1, 23 pp. Mimeo (rev.)

Somewhat outdated, but still usable, general information on the farming details of propagating wild millet, smartweeds,

bulrushes, and several other marsh emergents and aquatics. This poorly written mimeo leaflet deserves updating, re-writing, and reprinting in readable format.

USF&WS. 1950. Development and management of dike cover. USF&WS, Branch Wildl. Ref., Wildl. Mgt. Ser. 1A, 29 pp. 1 map. Mimeo.

Twenty-year-old leaflet still has useful general information. Lists, by geography and habitat types, suitable plants for stabilizing dikes, dams, and dunes, as well as for providing wildlife food and cover. The leaflet should be updated and re-issued in a livelier, more readable format.

Weaver, R. A., F. Vernoy, and B. Craig. 1959. Game water development on the desert. Calif. Fish and Game 45(4):333-342.

Details how to: improve marginal springs or water seeps with ramps or shade; use water-indicating plants as key to development sites; develop areas with hand tools, dynamite, or chemicals and fire; plan construction and maintenance of desert water areas. Although the emphasis is on upland and big game animals, these techniques may apply to wetland development.

Weir, W. W. 1949. Land drainage. Univ. Calif. Agr. Ext. Svc. Circ. 391, 24 pp.

The pamphlet is 20 years old and some construction methods are outdated, but the principles discussed are sound. Herringbone, gridiron, intercepting, and natural systems of open ditches and tile drains are described. Ditch profiles with details of recommended side slope, sizes, construction and maintenance of open ditch types are given. Good design features of a tiled system with notes on spacing, grade, discharge-tile sizes are included. Brief mention is made of drain accessories: pumps, outlets, inlets, man-holes, and joints.

Williams, S. and G. H. Jensen. 1945. A versatile boat for waterfowl management and research. J. Wildl. Mgt. 9(3): 163-169.

The first account of the now-familiar marsh management tool--the propeller-driven air boat, invented by Williams and Jensen.

Yocom, C. F. 1952. Techniques used to increase nesting of Canada geese. J. Wildl. Mgt. 16(4):425-428.

Describes elevated platform nests made of chicken wire, of woven willow baskets, of metal washtubs. Cites use: 53 artificial nests available in spring had 12 with eggs and "geese...seen" in others.

SECTION D

WETLANDS VEGETATION

Section D, 62 citations, includes those papers that, in their study of various wetlands problems, emphasize particular plant groups, genera, or species. Often it is a matter of personal opinion whether one of these papers is more logically placed here than in another section.

Anderson, J. M. 1950. Some aquatic vegetation changes following fish removal. J. Wildl. Mgt. 14(2):206-209.

A companion piece to the article by Weir and Starr. Removal of rough fish from lake by Rotenone treatment cleared water and promoted growth of aquatic vegetation. Emergent and floating-leaved species showed no change.

Atkins, M. D. 1958. Cover on watershed dams. J. Soil & Water Cons. 13(5):220-221.

To prevent erosion on newly built earth dams, mulch the surface about 1.5" deep, anchor the mulch with notched coulter disks, sow to bermudagrass or perennial native grasses, and sprinkler-irrigate from the adjacent reservoir. This method gives more certain results than sowing directly to perennials or to quick-growing annuals like sudangrass or other grain. (See Bartee, 1964.)

Barbehenn, K. 1954. The effects of ducks on the development of filamentous algae in farm fishponds. N. Y. Fish and Game J. 1(1):110-115.

Under normal conditions, neither mallards nor domestic ducks eat enough algae to reduce development of algal growth. Where mallards are highly concentrated the activity of the birds may reduce or break up the algal mat or, by causing water turbidity, may slow down algal development. But ducks alone cannot serve as a management tool to control filamentous green algae.

Beadle, N. C. W. 1952. Studies in halophytes. I: The germination of the seed and establishment of the seedlings of five species of Atriplex in Australia. Ecology 33(1):49-62.

Since exotic as well as native saltbushes have become successfully established in western U. S. and are valuable waterfowl and game bird forage, this detailed study is of value to wetland ecology. Responses to three irrigation treatments are discussed; the viability of hard and soft seeds is checked. The action of chloride in retarding germination is explained.

Bedish, J. W. 1967. Cattail moisture requirements and their significance to marsh management. Am. Midl. Nat. 78(2): 288-300.

A hybrid cattail, resulting from a natural cross of Typha latifolia and T. angustifolia, was studied under greenhouse and field conditions to determine optimum soil moisture and

water depth for germination, growth, and vegetative reproduction. No differences in germination were noted between water depths of 1" and 6". Germination was reduced 50% by storage of seed for one year at room temperature and humidity. Vegetative reproduction was similar in saturated soil and in soil flooded 1" to 6" deep.

Beetle, A. A. 1950. Bulrushes and their multiple uses. Econ. Bot. 4(2):132-138.

The genus Scirpus is discussed. Moses was probably hidden in Cyperus (papyrus), not Scirpus, but man has found many uses for bulrushes as material for mats, baskets, boats, thatch, and fiber. The value of various bulrushes for wildlife food and cover is well known. The tubers and rhizomes were, and still are, eaten by many people. Indians of North and South America roast and eat the tubers of S. paludosus; tule is eaten in India. Many Scirpus species are good cattle forage. In horticulture there is some slight use of the genus; the author suggests that certain decorative South American types should be investigated. Some weedy or obnoxious members of the genus are noted.

Byrd, M. and W. C. Young. 1960. Browntopmillet for wildlife. Soil Cons. 26(2):34-35.

Browntopmillet was successfully grown for waterfowl and wildlife forage in Mississippi, Louisiana, and Arkansas. Seed was planted in June and July. The crop did not demand heavy fertilizing, except on poorer soils, although generally the plantings were fertilized at rates standard for local grain crops. High nitrogen rates produced lush vegetative growth but scant seed. Normal plantings yielded from 1,800 to 2,800 lbs. per acre. A late (August) planting yielded 250 lbs. per acre. In Louisiana, the browntopmillet was combine-harvested and the stubble field was flooded during duck season. Forty acres held 7,000 ducks for three weeks and about 100 per week thereafter.

Chamberlain, E. B. 1948. Ecological factors influencing the growth and management of certain waterfowl food plants on Back Bay National Wildlife Refuge. Trans. 13th N. Am. Wildl. Conf.:347-356.

Production of submerged aquatic plants was far below area's potential. Major factor was water turbidity resulting from wind and waves. Rooting and feeding by carp was a contributing factor. Management suggestions: prevent pollution, reduce carp population, encourage emergent plant species.

Classen, P. W. 1921. Typha insects: their ecological relationships. Cornell Univ. (N. Y.) Agr. Expt. Sta. Mem. 47: 459-529, 20 pls.

A monograph on cattail and the insects associated with this plant.

Crail, L. R. 1951. Viability of smartweed and millet seed in relation to marsh management in Missouri. Mo. Cons. Comm. P-R Report 3, 16 pp.

Early summer drawdowns to expose mud flats on which duck food plants will appear have become standard management practice in Central Flyway states. A combine (Dill, 1948) was used to harvest seeds of millet and smartweed. But the wild millet (Echinochloa crusgalli) and smartweed (Polygonum pennsylvanicum) did not germinate satisfactorily, and Japanese millet (E. crusgalli var. frumentacea) did not reseed. A two-year study gave the answers. Flooding killed the Japanese millet seed. Wild millet and smartweed ripen irregularly; the combine harvested these before many were ripe (to avoid loss by shatter) and these unripe seeds died. Dry-stored millet and smartweed seed loses viability. Japanese millet will air-dry, store, and keep, but it must remain cool and dry. Post-drawdown disking in May or June was detrimental to development of natural stands. Results on exposed mudflats: exposure in late May--rank growth of smartweed; exposure in early June--wild millet, heavy growth; exposure in mid- to late June produced chufa, annual weeds, and thin stands of wild millet. Author recommends fall seeding for wild millet and smartweeds, but only in areas lacking volunteer seed supply.

Deem, A. W. and F. Thorp, Jr. 1939. Toxic algae in Colorado. J. Am. Vet. Med. Assoc. 95:542-544.

Lake in Weld County, Colorado, lost tame ducks to algae poisoning (Anabaena flos-aquae). Wild birds were also found dead, but no mortality figures are given.

Duthie, H. C. 1965. Study of the distribution and periodicity of some algae in a bog pool. J. Ecol. 53:343-359.

A vertical distribution of desmids and diatoms is recorded from the sediment of a bog pool. The desmid flora over an area of bog sediment varies with the sediment type and with the macrophytes. The relation between algal communities and bog water, as well as the succession of desmids, is noted.

Emerson, F. B., Jr. 1962. The vascular plants of some marshes created for wildlife in southcentral New York. New York F. & G. J. 9(1):37-43.

A list of 139 plants is presented with dominance, frequency, and abundance of species noted. Mesophytic dike species are mentioned. This paper will interest western marsh ecologists mainly for the insight into the ubiquitous species with wide tolerances and for the fact that so many typical western marsh species are absent from the generally acidic marshes and ponds of this study.

Fergus, C. L., W. M. Sharp, and E. Decker. 1956. The role of plant diseases in wildlife food plants: a smut on dotted smartweed. Plant. Dis. Reporter 40(11):1017-1018.

A smut (Ustilago utriculosa) attacked Polygonum punctatum in a Pennsylvania marsh. Spikes averaged 373 per sq. yard; 5.6% of seed-bearing spikes were ruined by smut. The loss was not serious, but the authors point out that such plant diseases have been destructive elsewhere and recommend further investigation of plant disease as a factor in management.

Finfrock, D. C. and M. D. Miller. 1958. Establishing a rice stand. Univ. Calif. Agr. Ext. Svc. Leafl. 99.

This map-fold illustrated leaflet outlines cultural practices important to establishing a rice stand.

Finfrock, D. C. and M. D. Miller. 1959. Wild rice. Univ. Calif. Agr. Ext. Svc. Leafl. 116.

An illustrated map-fold leaflet that describes wild rice, Zizania aquatica L., its native habitat in North America, and recounts attempts to establish this plant in California. Results generally have been unsuccessful, although the Biggs (Calif.) Rice Experiment Station reports seed yields of about 500 lbs./A. in 70 days after seeding. Seed shatters badly and is easily lost. The authors suggest only "test plot"-sized attempts, pending further research. However, for wild rice culturists, information is supplied on how, when, where, and how much to seed; where to buy the seed; and how to harvest. Wild rice is normally found in sluggish, muck-bottomed waterways or in acidic bogs. The plant is salt-intolerant, the authors state.

Finfrock, D. C., K. L. Viste, W. A. Harvey, and M. D. Miller. 1958. Weed control in rice. Univ. Calif. Agr. Ext. Svc. Leafl. 97.

A map-fold leaflet whose major value to the wetlands wildlife manager is the series of photographs of marsh plants: rough-seed bulrush, river bulrush, purple ammania (redstem), waterplantain, burhead, arrowhead, small flowered umbrella plant (nutgrass, Cyperus sp.), spike sedge (spikerush, Eleocharis sp.), knotgrass (jointgrass, Paspalum distichum) and bearded sprangletop (Leptochloa sp.). Of particular interest is the photo illustrating six different head-types in watergrass (wild millet, barnyard grass, Echinochloa crusgalli).

Gates, F. C. 1948. Colonization of certain aquatic plants on an open shoal. Ecology 29(2):205-208.

Marsh emergents, such as Scirpus acutus and Eleocharis macrostachya, were planted on submerged flats and shoals in Douglas Lake, Michigan. Plantings were successful on the edge of flats free from wave action and unsuccessful on a storm-swept shoal.

George, H. A. 1963. Planting alkali bulrush for waterfowl food. Calif. Dept. F. & G. Game Mgt. Leafl. No. 9, 9 pp.

Describes alkali bulrush, Scirpus robustus, and its value as waterfowl food. Discusses culture and management practices. Notes that seed germination can be hastened if seed is soaked for three days in standard (5%) household bleach diluted 1 to 5 with water. Sow wet seed on mud flat at 30 lbs./A. The booklet discusses seeding dates and water management.

Givens, L. S. and T. Z. Atkeson. 1952. Use of Italian rye grass as a means of attracting waterfowl. J. Wildl. Mgt. 16(1):107-108.

Water reservoir mudflats, subject to severe fluctuation in water levels, were successfully planted to annual Italian rye grass, Lolium multiflorum, as a supplementary attraction to waterfowl on the Wheeler National Wildlife Refuge (Tennessee Valley, Alabama)--an area of heavy rain, mild winters, and fertile soil.

Grizzell, R. A., Jr., and W. W. Neely. 1962. Biological controls for water weeds. Trans. 27th N. Am. Wildl. Conf.: 107-113.

Biological field-testing of two genera of filamentous algae, Pithophora (fresh water ponds) and Cladophora (brackish water ponds), showed effective control of Pithophora in bass-bluegill ponds by using 5 to 6-inch Israeli carp (Cyprinus carpio) at a rate of 50 per acre; Cladophora was controlled in widgeongrass duck ponds by fingerling mullet. Stocking rates are not known. Study also reports that six or more Muscovy ducks per acre will control duckweeds (Lemna, Wolffia, and Spirodela) in ponds.

Gysel, L. W. 1954. The value of safflower as a wildlife food plant in Michigan. Michigan Agr. Expt. Sta. Quart. Bull. 36(4):374-377.

Two commercial varieties of safflower, N-6 and N-8, showed most promise as winter food for wildlife in southern Michigan. Seed production varied greatly according to soil quality and plant competition.

Harris, S. W. and W. H. Marshall. 1960. Germination and planting experiments on soft-stem and hard-stem bulrush. J. Wildl. Mgt. 24(2):134-138.

Five storage and three germination conditions were tested on three lots of soft-stem bulrush and one lot of hard-stem bulrush seed. No germination was noted after seven months' storage in any of the tests. Seed stored in natural water had the highest germination percentages. Plantings made in the fall were most successful in developing stands of seedlings the following spring and summer. Two methods of combining drawdown operations and bulrush seeding were suggested.

Hartman, R. T. and D. L. Brown. 1967. Changes in internal atmosphere of submersed vascular hydrophytes in relation to photosynthesis. Ecology 48(2):252-258.

Gases were extracted from the internal atmosphere of Elodea canadensis and Ceratophyllum demersum in a closed system under reduced pressure. Gases measured by gas chromatography included CO_2, O_2, and NH_2. Confirmation that carbon was being fixed by these plants cast further doubts on the reliability of using changes in dissolved O_2 as a sole measure of photosynthetic activity in aquatic ecosystems.

Haskin, L. L. 1927. The versatile cattail. Nature 10:178-180.

Cattails have been, and still are in some places, widely used by the American Indians. The starchy rhizomes, particularly in autumn, are roasted, boiled, eaten raw, or ground into flour. In spring, the American Indians (and the Russian Cossacks) boil the tender shoots like asparagus. The green staminate head is eaten boiled; flour is made from the pollen. Cattail leaves and stems are used for mats, thatch, sails, and are bundled for boats and floats.

Hodge, W. 1956. Chinese water chestnut or matai--a paddy crop of China. Econ. Bot. 10(1):49-65.

Eleocharis dulcis, a large sedge known as the Chinese water chestnut, is cultivated in China to produce large edible corms--a crop of great economic value grown in conjunction with rice culture. The author outlines the history and culture of this marsh plant and cites recorded introductions to the United States. Since the federal embargo on commercial shipments from China (1950) interest in water chestnuts is increasing. Requirements cited for this annual crop are controlled irrigation ponds and a climate that has at least 220 days annually frost-free. Soil and water quality criteria are not given.

Hunt, G. S. and R. W. Lutz. 1959. Seed production by curly-leaved pondweed and its significance to waterfowl. J. Wildl. Mgt. 23(4):405-408.

Potamogeton crispus is an exotic pondweed of purported low value as duck food since it seldom seeds in N. America, spreading generally by vegetative growth or by winter buds. Authors find drastic drawdown of ponds in a Lake Erie marsh duck club forced the plant to seed. Deep water appears inimical to seeding. Authors recommend 3" to 12" depth for maximum seed production of 125 lbs./A. The seed is a major duck food item, wherever available.

Ingram, W. M. and G. W. Prescott, 1954. Toxic freshwater algae. Am. Midl. Nat. 52(1):75-87.

An erudite synopsis of the history, etiology, and literature on toxic blue-green algae. The emphasis is on the human health hazard (not proved) and on stock poisoning by Cyanophyta. Topics covered are: public health aspects, toxicity to domestic animals, laboratory studies of toxicity to test vertebrates, and chemistry of toxic algae.

Isley, D. 1944. A study of conditions that affect the germination of Scirpus seeds. Cornell Univ. (N.Y.) Agr. Expt. Sta. Mem. 257, 28 pp.

The behavior of the seeds of 14 species of Scirpus was studied in relation to various storage and germinative conditions. Reactions varied for the different species, but in general all the bulrush seed tested showed that pregermination treatment was needed. Seed lots stored at room temperature, either dry or in water, did not germinate. Storage in water 2 - 4° C. gave good germination for species with small achenes; species with large achenes were variable and unsatisfactory. Scarification did not speed up the rate or increase the percentage of germination. Many species of Scirpus have extended period of viability.

Jacobs, D. L. 1947. Ecological life history of Spirodela polyrrhiza (greater duckweed) with emphasis on the turion phase. Ecological Mono. 17(4):437-469.

Comparatively little is known of duckweed ecology and little management is ever attempted for this valuable wildfowl food plant. This definitive study of one of the duckweed species details the influence of environment on critical phases of the plant's life history. The study notes: methods of dispersal (water currents, wildfowl, aquatic mammals), use (by fish, birds, mammals, invertebrates), competition, phenology, effects on environment. A detailed morphological study is given and the turion phase (reproductive flowering frond) is described and subjected to environmental experimentation. The study does not touch upon field management of the plant.

Joanen, T. and L. L. Glasgow. 1965. Factors influencing the establishment of wigeongrass stands in Louisiana. Proc. 19th Ann. Conf. S. E. Assoc. G. & F. Comm.:78-92.

Wigeongrass, Ruppia maritima, is a high value waterfowl food aquatic plant. Physical factors (turbidity, fluctuating water levels, and water depth) control new stands and the production on old stands. Optimum water depth for the plant is 24"; acceptable turbidity range is 25-54 ppm. Chemical factors (soluble salts in soil and water) inhibit seed germination by increasing osmotic pressure. Tolerable salinity range was 2,075 - 18,500 ppm. Other factors of water quality and soil chemistry had little effect on the plant's growth. Tolerable temperature range for growth was 18.5° C. to 30° C. Above or below this temperature growth ceased. Most important biotic factor noted was algae which blanketed the pond, reduced light, and crowded out the wigeongrass.

Jones, B. J. and J. B. Brown, rev. by M. D. Miller and L. J. Booher. 1949. Irrigated pastures in California. Univ. Calif. Agr. Ext. Svc. Circ. 125, 54 pp.

This paper deals with costs, land preparation and irrigation, seedbed preparation and planting, pasture management, legumes and grasses to be used, and control of livestock diseases and parasites on irrigated pastures. No mention is made in this early (1949) paper of integrated wildlife use.

Jones, J. W., L. L. Davis, and A. H. Williams, 1950. Rice culture in California. USDA Farm Bull. 2022, 32 pp.

Besides culture of rice, the booklet describes rice field weeds useful as waterfowl food and cover. Rice crop depredation by waterfowl and blackbirds is also described.

Jones, L. G., M. D. Miller, J. R. Goss, and M. L. Peterson. 1957. Sudangrass. Univ. Calif. Agr. Ext. Svc. Circ. 462, 18 pp.

Sudangrass is widely grown in California for pasture, hay and seed. This pamphlet briefly outlines the nature and adaptation of this sorghum, where it will grow, management practices, etc. Some developed varieties are discussed and the farming machinery needed is pictured. The circular warns of the occasional lethal prussic acid buildup in this cattle forage plant. (Not mentioned is the widespread use of this plant for wildlife and waterfowl food and cover. The rapid (10 day) deterioration of the flooded seed should be kept in mind by wetlands managers. P.H.A.)

Knowles, P. F. and M. D. Miller. 1960. Safflower in California. Univ. of Calif. Agr. Ext. Svc. Manual 27, 23 pp.

Safflower, Carthamus tinctorius L., is a winter annual of the thistle tribe that has become widely grown in the west for its seed oil. This pamphlet outlines cropping information, cultural practices, etc. Not mentioned is the plant's subsidiary value as wildlife food and cover. (N.B. The dry stubble produces excellent dove food and hunting, the flooded stubble provides waterfowling. P.H.A.)

Krecker, F. H. 1939. A comparative study of the animal population of certain submerged aquatic plants. Ecology 20(4): 553-562.

Seven common submerged aquatics were compared for average animal populations on samples based on 10 linear feet of stem and leaves. Counts were made in laboratory while

animals were alive and on the plants. All genera and most species (amphipods, insects, oligochaetes, gastropods, bryozoa, nematodes, turbellaria, hydra, and spongilla) were uniformly present on all plants, but number of individuals varied widely, indicating plant preference by animals. Myriophyllum spicatum, Potamogeton pectinatus, P. crispus, P. compressus, Elodea canadensis, Naias flexilis, and Vallisneria spiralis were the species studied. Midge larvae and oligochaetes composed 59% - 93% of population in most instances.

Kubichek, W. F. 1940. Collecting and storing seeds of waterfowl plants for propagation. Trans. 5th N. Am. Wildl. Conf.:364-368.

Discusses methods of collecting relatively small quantities of seeds of waterfowl plants: alkali bulrush, wild millet, smartweed, sago pondweed, widgeongrass, duck potato, wild rice. Economic inflation and increased costs of labor and materials have outdated this paper, although basic principles are sound.

McMillan, C. 1959. Salt tolerance within a Typha population. Am. J. Bot. 46 (July):521-526.

Population dynamics of Typha on a disturbed salt flat were studied in the field. Clones of T. angustifolia tended to occupy the drier sites and those of T. latifolia occupied the wetter sites. Hybrid clones were distributed with both T. angustifolia and T. latifolia. Rhizomes taken from the clones were grown in various NaCl solutions in the greenhouse. Results indicated greatest salt tolerance by T. angustifolia and least by T. latifolia. The hybrids were intermediate in salt tolerance. Seeds of the three clone types germinated over the same range of salt concentration. The seeds of all three types withstood four months' submergence in 2% salt solution and germinated upon being returned to tap water. During the drought years 1956-57, the clones of T. latifolia were not vigorous in the salt flat habitat. Some clones died or shrank back. The other two forms remained vigorous and even increased coverage. This study illustrates the effects of increased salinity acting selectively upon closely related but differing plant heredities.

Miller, A. W. 1959. Germination tests conducted during 1959 on alkali bulrush at Gray Lodge. Calif. Dept. F. & G. P-R W-30-R, 9 pp., Mimeo.

Waterfowl Research Project test ponds on Gray Lodge WMA (Sacramento Valley, California) were sown to treated and

control seeds of alkali bulrush, Scirpus robustus, and tuberosa bulrush, S. tuberosa. Findings: alkali bulrush seed soaked in 1:3 solution of household bleach (Clorox or other) for a period of 5 days, planted in early spring on mudflat, allowed to germinate and establish seedlings on mudflat, followed by shallow (1" to 5") irrigations, produced excellent establishment--from 60%-70% better stands than untreated control seeds. Tuberosa bulrush reacted similarly. A major problem in evaluating test results arose from the invasion of competing marsh plants, Cyperus sp. and Ammania sp.

Miller, A. W. and P. H. Arend. 1960. How to grow watergrass for ducks in California. Calif. Dept. F. & G. Game Mgt. Leafl. No. 1, 16 pp.

Watergrass, Echinochloa crusgalli, can produce an average yield of 1,500 lbs. of seed per acre; yields double this have been produced. Watergrass is alkali-tolerant, matures on three to four irrigations in 60-80 days. Planting and irrigation instructions are given; various pond layouts are described and illustrated; water management, grazing, and mosquito abatement are discussed. Other marsh plants, food and cover or noxious weeds, are described and illustrated.

Miller, H. W., O. K. Hoglund, and A. L. Hafenrichter. 1959. Grasses, legumes, and cultural method. Calif. Div. of Soil Cons. Bull. 1, 24 pp.

A fine-textured saline alkali soil near Los Banos, California (in the San Joaquin Valley Grasslands--a famous waterfowl area) had a deteriorated native cover of grasses and forbs. This cover was ploughed out; the land was leveled, treated with two rates of gypsum and with gypsum and manure, ponded, flushed with water, and seeded to a pasture mixture of Goar's fescue and narrowleaf trefoil. In addition, 17 grasses and 6 legumes were seeded to pure stands and tested. Three cuttings of hay were taken in first and second growing seasons, and the pastures were grazed with dairy cattle third and fourth seasons. Details are given of yields with various additive and fertilizer rates, of grazing days and butterfat yields. Among the test plants, Goar's fescue, tall wheatgrass, and hardinggrass were best grasses and narrowleaf trefoil best legume.

Miller, M. D., C. W. Schaller, and P. C. Berryman. 1961. Growing wheat in California. Univ. Calif. Agr. Ext. Svc. Manual 29, 27 pp.

This technical manual is a useful reference for the wetlands

manager engaged in grain production for waterfowl forage. The soil management outlines and the varietal performances may be of particular interest.

Moyle, J. B. 1944. Wild rice in Minnesota. J. Wildl. Mgt. 8(3):177-184.

A general survey of the distribution and economic uses of wild rice to both man and wildlife. Harvest failures are usually attributed to high water levels during May and June. Average production in Minnesota is about 30 to 40 pounds of processed wild rice per acre.

Muenscher, W. C. 1936. The germination of seeds of Potamogeton. Annals Bot. (Series 1) 50:805-821.

An erudite and carefully detailed study on 18 species of pondweeds makes a point of importance to practical marsh management: A number of species of the genus Potamogeton produce viable seeds, capable of germinating without undergoing a long rest period, provided the seeds are not allowed to become dry.

Neely, W. W. 1960. Managing Scirpus robustus for ducks. Proc. 14th Ann. Conf. S. E. Assoc. G. & F. Comm.:30-34.

Based upon field work in the southeastern states, on brackish water areas, the production of saltmarsh bulrush for waterfowl food and cover is discussed. The fields used in the trials were not tilled or seeded. Existing clones of the bulrush or of dried stubble indicated that, at some time prior to the trials, the plant had grown and shed seed in the area. The sole management practice was, first, to insure by water gates, etc., that water control was obtained and, second, to begin to fluctuate water levels in the spring. The water was gradually raised to a depth of 6" - 8" and then gradually dropped to a saturated soil level. The flooding was repeated at 30-day intervals. By fall, a scattered growth of S. robustus had emerged all over the fields and in some places heavy beds appeared. Fruiting was good, but few ducks used the area the first year. At the end of six years one trial field of 125 acres had a nearly solid stand, although some openings in uneven areas remained. After a steady yearly buildup, waterfowl use the area heavily and provide successful hunting. Cost of management, other than outlay for dikes and water control, has been for minor labor to manipulate the water controls.

Northrup, King, & Co. 1960. NK37 bermudagrass, new promise for alkali land. Northrup, King & Co. Case History Report #520, 1 p. leaflet.

This is an example of information available through the customer service departments of many commercial firms. In June, 1959, NK37 was planted 2.5 lbs./A. on 120 acres of newly scraped, alkaline soil. Seed was broadcast and followed with cultipacker. No fertilizer or amendment was used. Stand established readily and grazing began 60 days from seeding. Light, frequent irrigations, 2-3 days apart, were given until stand was established. In November, the 120 acres were disked lightly and overseeded with 50 lbs. of barley and 25 lbs. Merced rye; 50 lbs. nitrogen were added and the land was irrigated. Beginning February 1, 80 acres were pastured; the remaining 40 acres were cut for hay in April, yielding 50 tons. When overseeded crop was harvested in April the NK37 resumed rapid growth and production.

Pearson, H. S. 1952. Cattails. Nature 45(1):33.

Brief, popular article describes the plant and habit, and cites several uses for food, fiber, and padding.

Peterson, M. L., L. G. Jones, and V. P. Osterli. 1953. Birdsfoot trefoil, Univ. Calif. Agr. Ext. Svc. Circ. 421, 15 pp.

This 16-year-old pamphlet provides still usable information on the varieties, requirements, cultural practices, and pasture management of birdsfoot trefoil, a fairly salt-tolerant legume that has a firm place in management for upland game and waterfowl. No wildlife use is referred to in this circular, however.

Robel, R. J. 1961. Water depth and turbidity in relation to growth of sago pondweed. J. Wildl. Mgt. 25(4):436-438.

Strong correlations were found between vegetation production and water depth, water depth and turbidity, and turbidity and vegetation production. Deeper waters contained less suspended matter and supported larger crops of aquatic vegetation.

Robertson, J. H. 1955. Penetration of roots of tall wheatgrass in wet saline-alkali soil. Ecology 36(4):755-756.

Agropyron elongatum produces high pasturage yields and grows better than many other grasses on wet saline-alkali soils. Near Lovelock, Nevada, stands of tall wheatgrasses growing

with saltgrass, Distichlis stricta, were studied at two locations; one, a vigorous stand of wheatgrass where the water table stood at 12 feet; the second, of poor quality (attributed to higher salinity, alkalinity, and sodium content in upper 2 feet of soil) where water table stood at 10 feet. Save for 12-foot level in first site, all levels were 8.7+ in pH, indicating high exchangeable sodium percentage and alkaline-earth carbonates ("Black alkali"). Saltgrass roots in each location extended to 27 inches; wheatgrass roots to approx. 9 feet in poorer location, nearly 11 feet in better location. Roots were less numerous at comparable levels in that profile which showed highest percentage of salt and sodium, and highest pH reaction.

Rose, E. T. 1952. The blue-green algae problem in Iowa lakes. 14th Midwest Wildl. Conf., Des Moines, Iowa:1-12.

Prairie states and provinces often have toxic water in ponds or lakes infested with certain blue-green algae. Toxicities of several genera and species have been recorded. Anabaena flos-aquae was responsible for known losses at Storm Lake, Iowa, in the fall of 1952: 5,000 to 7,000 gulls, 560 ducks, 400 coots, 200 pheasants, 50 fox squirrels, 18 muskrats, 15 dogs, 4 cats, 2 hogs, 2 hawks, 1 skunk, 1 mink, and many songbirds. Copper sulfate treatment was effective but costly. Treating algal concentrations along the lake margin gave effective control. Treatment rate was 1 ppm (volume), 2-3 treatments per year. Although decaying algae stink, they are then less lethal than when healthy and sporulating.

Schaller, C. W. and M. D. Miller. 1960. Barley production in California. Univ. Calif. Agr. Ext. Svc. Manual 28, 29 pp.

This manual provides general information on barley growing in California. Dry land and irrigation farming are discussed. Seedbed preparation, harvesting, storage, diseases and insect pest control for barley are investigated. A summary of the major barley varieties used in California is included. Waterfowl managers who often farm wetlands to grain for duck forage will find this a useful reference.

Sharp, W. M. 1939. Propagation of Potamogeton and Sagittaria from seeds. Trans. 4th N. Am. Wildl. Conf.:351-358.

Deals with the collecting, storing, and field planting of pondweeds, Potamogeton pectinatus and P. zosteriformis Fernald, and of duck potato, Sagittaria latifolia, in Nebraska. (Since the operation depended on cheap hand-labor,

the method described is no longer economically feasible on a large scale.) Extremely dry seasons hinder pondweed fruit development but aid the duck potato crop. Duck potato is injured by early freezes; pondweeds are unaffected. Of several species of pondweeds only P. pectinatus and P. zosteriformis produce enough seed to justify harvesting, the author states. Duck potato is stored in the fall on platforms, pondweed seeds and buds in tanks of flowing water.

Stanton, F. W. 1957. Planting food for waterfowl. Ore. State Game Comm. Misc. Wildl. Publ. No. 1, ii and 17 pp., 3 figs.

North Dakota crop plants and aquatics used by waterfowl are reviewed by species. Site selection, cultivation techniques, seeding dates and rates, costs and per acre yields, and use by waterfowl are outlined.

Steenis, J. H. 1939. Marsh management on the Great Plains Waterfowl Refuge. Trans. 4th N. Am. Wildl. Conf.:400-405.

Describes the heyday of the CCC and WPA period of the Biological Survey, when unlimited cheap labor was available for collecting, storing, and planting of marsh and aquatic herbs. Methods described are economically infeasible today, but notes on storage and treatment of seed and root stock may be useful.

Steeves, T. A. 1952. Wild rice--Indian food and a modern delicacy. Econ. Bot. 6(2):107-142.

This excellent treatise deals with a plant of almost no present importance to western wetland ecology, but with considerable potential. The history of the plant in Indian culture, its present economic status, the wildlife values, and botanical ecology are discussed in detail. The author states that some strains of Zizania aquatica have vastly different ecological tolerances, and he notes that, although wild rice is absent from strongly alkaline waters, it will tolerate salt (NaCl) and grows in tidal estuaries. Wild rice is intolerant of sulphate over 10 ppm and is unsuited to stagnant water.

Stoddard, C. H. 1960. Wild rice production from new wetlands, with discussion. Trans. 25th N. Am. Wildl. Conf.:144-153.

The physical and chemical factors for optimum wild rice growth are: slow flowing water, water depths of 6 in. to 4½ feet, nearly constant water levels during growing

season, alkalinity of 40 - 200 ppm, neutral pH (6.8 - 8.8), surface ionization below 10 ppm, and high organic content of soil. Cultivation of wild rice as a crop in Minnesota and Wisconsin is discussed.

Taschdjian, E. 1954. A note on Spartina protein. Econ. Bot. 8(2):164-165.

Sloughgrass or cordgrass (Spartina spp.) are found along ocean coasts in tidal mudflats. They are mud-binders and are important factors in the natural reclamation of salt marshes. In some areas Spartina is locally important as stock forage, although this use is limited because of the mucky habitat. The author tested samples of Spartina for protein content and found it compared favorably with timothy hay as an extractable vegetable protein. If economical harvesting methods and palatable dietetic preparations can be devised, Spartina may become a valuable source of protein from marshlands.

Teeter, J. W. 1965. Effects of sodium chloride on the sago pondweed. J. Wildl. Mgt. 29(4):838-845.

Sago pondweed plants, Potamogeton pectinatus, were subjected to various concentrations of NaCl. Stronger NaCl solutions produced adverse effects upon vegetative growth and seed production, but a NaCl concentration of 3,000 ppm stimulated growth of tubers. Tap water treatment produced maximum seed germination success; and a salt concentration of 3,000 ppm reduced germination success by 50%. Tubers exposed to a concentration of 3,000 ppm produced more rhizome shoots than tubers in any other treatment, indicating that tubers obtain some beneficial effect from the low saline environment. All phases of this study were conducted in a greenhouse--a fact to consider in field application.

USDA. 1961. Growing safflower--an oilseed crop. USDA Farmers' Bull. No. 2133, 15 pp.

Information is similar to that in Knowles and Miller, 1960, but applies to several western states, not just to California.

Williams, C. S. and W. E. Marshall. 1938. Evaluation of nesting cover for waterfowl on Bear River Refuge. Trans. 3rd N. Am. Wildl. Conf.:640-646.

This study assigns index values of ten marsh plant cover types to different waterfowl species. Hardstem bulrush

was least extensive but most used of four major associations. Alkali bulrush, although covering 59% of marsh, had least value for nesting cover. Saltgrass, 26% of marsh, ranked next to hardstem bulrush. Cattail, 6% of marsh, ranked third. Phragmites, willows, weeds, and other cover types are indexed. All waterfowl species do not have the same cover preference. Muskrat houses, eat-out ponds, water depths are important. More than 2/3 of nests were located in cover types that cover less than 10% of marsh.

Wisconsin Conservation Department. 1955. Are cattails to become paying wetland crop? Wisc. Cons. Bull. 20(11):8.

Syracuse University scientists, working on commercial uses of cattail, find that cattail rhizomes can be eaten like potatoes or ground into flour. Rhizome production can reach 140 tons/A. or ten times that of potatoes. Cattail flour yield is 32 tons/A. and the flour can be converted to ethyl alcohol. Fiber yields of cattail stems are 40% of dry weight, other plants produce 6%. Cattail spikes yield kapok-like filling; seeds process to oil. Many other uses are listed. The major problem is the lack of commercial markets and efficient harvesting methods on wetlands.

SECTION E

WETLAND ANIMALS--EXCLUDING WATERFOWL

The 32 papers cited in Section E are a sampling of the sprawling literature on furbearers, fishes, poikilothermal vertebrates, and the invertebrates associated with wetlands ecology. The entries are largely restricted to citations directly pertinent to integrated management of waterfowl and wetlands.

Beard, E. B. 1953. The importance of beaver in waterfowl management at the Seney National Wildlife Refuge. J. Wildl. Mgt. 17(4):398-436.

This two-year study is an intensive, thoroughly detailed, and thoughtful minor classic on the ecology of beaver dams and waterfowl. The study concludes, "The beaver has set the pattern of optimum waterfowl environment. Management will be wise to copy it."

Bellrose, F. C., Jr. 1950. The relationship of muskrat populations to various marsh and aquatic plants. J. Wildl. Mgt. 14(3):299-315.

Food preferences of Illinois River Valley muskrats are reported. Emergent marsh plants (cattail, bulrushes, etc.) are preferred and also have the highest over-all plant value to the muskrat population. Other factors affecting muskrat population density and behavior are discussed. This paper has only moderate value to western wetlands study.

Bellrose, F. C. and L. C. Brown. 1941. The effects of fluctuating water levels on the muskrat population of the Illinois River Valley. J. Wildl. Mgt. 5(2):206-212.

Muskrat populations were affected more by seasonal water level change than by the type of vegetation. Cattail, even in low abundance, supported more muskrats per unit area than did other plants. The following plants were also found to be of value to muskrats: river bulrush, marsh smartweed, wild rice, and American lotus.

Brenner, F. J. 1966. The influence of drought on reproduction in a breeding population of redwinged blackbirds. Am. Midl. Nat. 76(1):201-210.

An intriguing study records the effects of drought on a Pennsylvania marsh and on its breeding blackbirds. During a five-year drought (6.55" below average rainfall each year), a cattail-sedge marsh changed to sedge-dominant marsh. Territorial male redwinged blackbirds remained at the same population level during the drought, but females dropped to 18% of normal and the young declined to 15%. Bird population size appears to correspond to energy available to population from insect food. Rainfall does not appear to be a stimulus for the timing of nesting activity for birds of the temperate deciduous forest biome, in contrast to tropical or xerophilic bird species. However, rainfall and its effects on the type of vegetation and on the insect biomass may regulate the birds' population size.

Cahoon, W. G. 1953. Commercial carp removal at Lake Mattamuskeet, North Carolina. J. Wildl. Mgt. 17(3):312-317.

In a national wildlife refuge, 1,600,000 lbs. of carp and catfish were commercially removed in a four-year period from 30,000 acres of open water and 20,000 acres of marsh. Gross sale value of the fish was approximately $150,000. Lake water clarity improved; submergent and emergent waterfowl food and cover plants re-established. Sport-fishing improved.

Coulter, M. W. 1957. Predation by snapping turtles upon aquatic birds in Maine marshes. J. Wildl. Mgt. 21(1): 17-21.

Despite the locale of this study, the results will interest the western wetlands ecologist who may have the problem of introduction or control of turtles in his waterfowl ponds. Snappers (weighing up to 41 lbs!) were live-trapped, shot, and their GI tracts were checked. Of 171 turtles, food was found in 157, and 1 in 4 had eaten birds. Up to 13% of estimated local duckling population was taken in 25 days or less. However, widespread turtle control is not recommended since significant duckling mortality is believed limited to ponds where both turtles and ducklings are abundant.

Dobie, J., O. L. Meehean, S. F. Snieszko, and G. N. Washburn. 1956. Raising bait fishes. USF&WS Circ. 35, 123 pp.

To put the preservation of wetlands on a sound economic base, auxiliary productive uses must be developed. One such use is explored in this circular. Topics discussed are: economic considerations, artificial and natural ponds, management and operation, and control of weeds, pests, predators, and disease. Twenty important bait fishes are illustrated and described in considerable detail.

Dorney, R. S. 1954. Ecology of marsh raccoons. J. Wildl. Mgt. 18(2):217-225.

A two-year study in Wisconsin on the relationships between raccoons, muskrats, and ducks emphasizes food habits of raccoons, particularly their feeding on trapped muskrats and crippled ducks.

Dozier, H. L. 1953. Muskrat production and management. USF&WS Circ. 18, 42 pp.

This circular discusses the biology and ecology of the muskrat, principles of marsh management for muskrat production, trapping, pelting, marketing, re-stocking depleted areas, live-trapping, banding, shipping, etc. Of particular interest, in view of muskrat control problems in the West and falling fur prices, is the section on muskrat meat as food (p. 33 ff.). Utilization of "marsh rabbit" or "Chesapeake terrapin" may provide another economic plank to support a wetlands management program. (See Dozier, H. L., Recipes for cooking muskrat meat, USF&WS, Wildl. Leafl. 229.)

Duffy, M. F. 1966. Catfish by the acre. (Reprint from La. Cons., May-June 1966). La. Wildl. Educ. Bull. 95, 15 pp.

Catfish farming in northeastern Louisiana on 4'-deep one-acre ponds can produce $200 net annual profit per acre. But it takes about 100 acres and $100,000 in capital to start off as a commercial success. Some ranchers start with as little as 15 acres and build up. Side products are bullfrogs, crayfish, and bait minnows.

Errington, P. L. 1961. Muskrats and marsh management. Stackpole Co. and Wildl. Mgt. Inst., 183 pp.

Gives a fair amount of information on muskrat behavior and biology; a great deal of practical information on muskrat trapping; very little detailed information on marsh management.

Errington, P. 1962. Muskrat populations. Iowa State Univ. Press, 664 pp.

More than 30,000 hours of field work and data assembled over 25 years have gone into this outstanding work. Part I deals with biology and behavior; Part II with case histories and observations centered in Iowa; Part III concerns geographic range of the species; Part IV, population dynamics.

Hickling, C. F. 1963. The cultivation of Tilapia. Sci. Am. 208(5):143-152.

This prolific fish, a cheap source of protein, may be easily grown in western U. S. on permanent, small, shallow fish ponds. New methods to grow larger individual fish are discussed.

Judd, W. W. 1953. A study of the population of insects emerging as adults from the Dundas Marsh, Hamilton, Ontario, during 1948. Amn. Midl. Nat. 49(3):801-824.

Between March 16 and November 20, 1948, 15,338 adult insects emerging from Dundas Marsh water were trapped in five cages--an average of 409 insects per square foot during the period. Diptera were (87.1%) most abundant; of these 92% were midges (Chironomidae). The trapping cages and collecting methods are described. This paper is important to western wetlands ecologists and research biologists since invertebrate productivity and ecology on western wetlands has not been widely reported.

Kobriger, G. D. 1965. Status, movements, habitats, and foods of prairie grouse on a sandhills refuge. J. Wildl. Mgt. 29(4):788-800.

Long, narrow wetland valleys of the sandhills of Nebraska are critical habitat areas for sharptail grouse and prairie chicken. Mowing these wetland meadows for hay sustains important food items like clovers, and maintains dancing and breeding grounds. Author suggests that a more tailored mowing, leaving strips and blocks of cover, will enhance the habitat.

LaCaze, C. 1966. More about crawfish. (Reprint from La. Cons., May-June 1966.) La. Wildl. Educ. Bull. 96, 16 pp.

In 1966, in Louisiana, 3,751 acres of swampland and 2,408 acres of riceland were devoted to crawfish farming, in five parishes west of the Atchafalaya Basin. Artificial impoundments specifically for crawfish farming were developed first about 20 years ago; now over 6,000 acres are devoted to this fishery. Management procedures for crawfish farming are outlined. Water management, stocking, and harvesting are discussed. The crawfish life cycle and a brief history of this fishing industry are given.

Lagler, K. F. 1956. The pike, Esox lucius L., in relation to waterfowl on the Seney National Wildlife Refuge, Michigan. J. Wildl. Mgt. 20(2):114-124.

An intriguingly contradictory paper on the study of pike predation, where only 3 waterfowl were found in 1,218 pike collected during 90-day duck brooding season. Despite this, pike control was established (by fishing). Arithmetic basis for control: out of every 500 pike "meals" one is a duckling; 60,000 fish on area eat 60,000 meals

daily, or 5,400,000 pike meals in season. Potentially, some 10,800 ducklings may be pike-bait. No correlated waterfowl production figures are given, but an angler and creel census is tabulated. The author suggests waterfowl production might be interfered with less by pike predation than by the disturbance of angler activity.

Neely, W. W. 1959. Snipe field management in the southeastern states. Proc. 13th Ann. Conf. S. E. Assoc. G. & F. Comm.: 288-291.

A good practical article that stresses the need to produce the preferred animal foods for the common snipe (jacksnipe) Capella gallinago. Snipe eat an 83% animal diet; earthworms, larvae, and snails are principal foods. Habitat must contain earthworms in rich, moist ground with only low cover. Most good snipe hunting fields are a lucky accident, but the habitat can be artificially developed in a level field, well mulched, well watered (puddled), and rich in earthworms and insect larvae. Vegetation must be kept low and dense. The manner of hunting is a part of the management. Gun pressure must be light and infrequent--no more than once a week is suggested.

Neely, W. W. 1962. Saline soil and brackish water in management of wildlife, fish, and shrimp. Trans. 27th N. Am. Wildl. Conf.:321-335.

In brackish water ponds on southeastern coast, bass and bluegills can grow in waters up to 8,000 ppm salinity, but cease to reproduce at 2,500-3,000 ppm. Managed salinity can thus control the population. Many sea species can be successfully impounded. Shrimp can produce up to 100 lbs./A. in small ponds. Larger ponds (25 A. or more) are being tested. The balance of the report is filled with odds and ends of valuable information, viz.: For ponds with salinities of 10,000 ppm widgeongrass is the best duck food. Dikes and water controls are needed. Saltmarsh bulrush is best emergent plant for this area. Snipe fields should be shallowly puddled, low in vegetation, rich in invertebrates. Goose pastures of marsh hay cordgrass require rotational burning. The cat-clay problem is discussed. A conversion table for salinity (read as ppm, millimhos, grains per gallon, % of sea strength, and ppt) and a tabulated plant/salinity tolerance chart are given. This is an excellent reference summary for brackish marsh management.

Neess, J. C. 1946. Development and status of pond fertilization in Central Europe. Trans. Amer. Fisheries Society 76:335-358.

Excellent resume of European pond culture. Reference is made to two German publications describing use of fish ponds for purification of sewage. The resulting large yields of rainbow trout and carp are utilized commercially for food.

O'Neil, T. 1949. The muskrat in the Louisiana coastal marshes--a study of the ecological, geological, biological, tidal, and climatic factors governing the production and management of the muskrat industry in Louisiana. Fed. Aid. Sec., F. & G. Div., La. Dept. Wildl. & Fish., xii and 152 pp.

The title tells it; sound and practical marsh management (for this area) is detailed.

Sather, J. H. 1958. Biology of the Great Plains muskrat in Nebraska. Wildl. Soc. Wildl. Mono. No. 2, 35 pp.

The monograph covers years of study in the sandhill lakes region of northcentral Nebraska, centered on the Valentine National Wildlife Refuge. Basic biological information was obtained from field observation, returns from tagged animals, physiological examination of specimens, food habits studies, etc. Age and sex ratios were obtained. Nestling young, nests and houses, movement and behavior (particularly early territoriality), disease, and predation were studied. Censuses of the population and the economic value of muskrat fur-trapping to Nebraska were noted. Indirectly the study develops considerable information on wetlands ecology.

Solman, V. E. F. 1954. The ecological relations of pike, Esox lucius L., and waterfowl. Ecology 26(2):157-170.

Pike are estimated to take 10% of the young waterfowl in the Athabaska and Saskatchewan River deltas.

Talbert, R. E. 1962. Controlling muskrats. Calif. Dept. Agr. Bull. 51(3):153-156.

Muskrats are prolific in the Central Valley of California and cause severe damage and loss to irrigation systems and waterways. Since fur-trapping fails to take enough of these animals to maintain control, other techniques are sought to prevent the damage or to remove the muskrats. The author recommends protecting headgates and control structures from burrowing at base or sides, by building

wings of concrete or metal. Dikes should be broad and extend at least 3 ft. above highest water. Repellents (calcium carbide, napthalene, drain oil) have been used. Eradication of weeds from canals and ditches removes muskrat habitat, unless ponds or marshes are adjacent. Various traps (steel #1 and #0, float traps, barrel traps, funnel traps) are described. Fumigants (carbon bisulphide) have controlled muskrats where drainage and exposure of runs in ditches is possible. Muskrat shooting by ditch-tenders and farmers is commended. Toxic baits (anticoagulants in rolled barley) floated in bait box have shown promise, the author states. (Since publication of this paper the "muskrat popsickle," a baited, wax-filled Dixie cup on a stick, thrust in the ground to a few inches above water level or on ditch banks, has had good results with no damage to waterfowl or other non-rodent wildlife. P.H.A.)

Thomas, C. H. 1963. A preliminary report on the agricultural production in the red-swamp crawfish. Procambarus clarkii Girard, in Louisiana rice fields. Proc. 17th Ann. Conf. S. E. Assoc. G. & F. Comm.:180-186.

After a period of field trials, rice and crawfish were successfully produced as rotation crops. Following late summer rice harvest, fields are reflooded 6" - 8" deep in September or October. Rice stubble volunteers. Crawfish spawn and are harvested from December through March. The field is then drained, ploughed, planted to rice (by May 1). Adult crawfish are stocked at a rate of 5-10 lbs./A. By August 1 rice is drained; crawfish estivate. By August 15 rice is harvested and the pond is reflooded to start the cycle over. As many as 1,000 lbs./A. of crawfish (average 25 to 30 per lb.) have been taken annually. Price is 10¢ to 35¢ per lb. live weight. There are 14 lbs. of meat per 100 lbs. of live crawfish. Peeled tail meat sells for $2.00 to $3.50 per lb. Harvesting methods and other management techniques are described.

Threinen, C. W. and W. T. Helm. 1954. Experiments and observations designed to show carp destruction of aquatic vegetation. J. Wildl. Mgt. 18(2):247-251.

Fencing carp from three Wisconsin lakes resulted in increased aquatic plant growth and water clarity.

USF&WS. 1963. Commercial possibilities and limitations in frog raising. USF&WS. Fish. Leafl. 436, 5 pp.

The leaflet states that artificial propagation of frogs on a commercial basis has not proved successful. Most so-called frog farms are natural marshes or ponds where frogs,

left to themselves, thrive and multiply. Increasing the shoreline by bays or peninsulas may increase production. Since adult frogs must have live, moving food, large-scale supplementary feeding of minnows, crayfish, or other small animals is difficult and expensive. Feeding trays are described, including the Japanese method of simulating live food by a water motor agitator. Rana catesbiana, the common bullfrog, and other edible North American frogs are described. The leaflet does not mention the recreation fishery potential of frogs in conjunction with waterfowl marsh development.

Warren, E. R. 1927. The beaver, its work and its ways. The Williams and Wilkins Co., Baltimore, xx and 177 pp.

One of a series of monographs on mammals, sponsored by the American Society of Mammalogists. An excellent account of the biology and behavior of the beaver.

White, K. L. 1953. This marsh is managed for production. Wis. Cons. Bull. 18(2):21-24.

A 234-acre Wisconsin hay marsh was managed for private wildlife. Water was controlled by a river dike; 12 miles of muskrat ditch were dredged; bleeder ditches, stumps, and logs were placed in marsh for habitat. Spoil banks were planted to food-bearing trees and shrubs. Minnow ponds were built. Production increments: muskrat harvest--35 in 1944, 1,400 in 1952; waterfowl breeding up; duck hunting good; rabbits abundant (in fact, a nuisance). Minnows were reared profitably in ditch ponds. Turtles were collected and sold. For several days each fall, 500 lbs. of frogs per day were harvested. This managed marsh was more profitable than if left natural, or drained and farmed.

White, M. and S. W. Harris. 1966. Winter occurrence, foods and habitat use of snipe in northwest California. J. Wildl. Mgt. 30(1):23-34.

Wilson snipe, wintering in Humboldt Bay region, were studied on coastal salt marshlands and on dairy pastures. The birds fed mainly on upland pastures, loafed and preened on salt marsh islands. Cover was low in all areas--a favorable condition for snipe. Food was 83% animal matter; this agrees with findings of other workers. It was noted that overgrazing by cattle, which lowers this area's waterfowl food value, resulted in higher value snipe habitat because of the low cover.

Whitney, L. F. and A. B. Underwood. 1952. The raccoon. Practical Science Publ. Co., Orange, Conn., 177 pp.

The adaptable raccoon is efficiently discussed; most aspects of his biology and ecology are touched upon, at least. The economic and commercial values are noted: uses for fur, as a laboratory animal, as a pet, meat, etc. Tips on care of captive raccoons are given.

Wisconsin Conservation Department, 1952. Carp as a food fish. Wisc. Cons. Dept. Publ. 219-52, 5 pp.

For the marsh manager struggling with a carp eradication program: eat your problems. Recipes are given for boiled, pickled, smoked, fried, and broiled carp. Methods of fleecing, dressing, filleting, and skinning carp are illustrated. Two home-made carp smokers are shown; one made from a 50-gal. metal drum, the other cleverly made from an old wooden icebox. The leaflet tells all except how to get rid of those sharp little bones.

SECTION F

WATERFOWL

The 119 citations in Section F emphasize the bird rather than the marshland, but all the papers--even those on production, food habits, disease, mortality, depredation, or the introduction of exotics--are selected for their pertinence to the ecology and management of western wetlands. General population reports and specious statements of waterfowl administration policies have been avoided.

Anderson, H. G. 1959. Food habits of migratory ducks in Illinois. Ill. Nat. Hist. Surv. Bull. 27(4):289-344.

An exhaustively detailed three-year study analyzes nearly 5,000 duck gizzards, representing 17 species. Of 95 wild plants and 4 cultivated plants found, the 20 most important plants were: coontail, corn, rice, cutgrass, marsh smartweed, wild millet, longleaf pondweed, red-rooted nut-grass, water-hemp, nodding smartweed, buttonbush, large-seed smartweed, nutgrass, chufa, Walter's millet, sago pondweed, duck potato, river bulrush, teal grass, and giant bur-reed. Food preferences of duck species and groups are detailed. The study notes the importance of grit and the fact that 200 of the 4,977 gizzards contained ingested lead shot. Food plants used are described and pictured. There is an adequate treatment of the invertebrates and other animal food components.

Anderson, W. 1956. A waterfowl nesting study on the Grasslands, Merced County, California. Calif. Fish and Game 42(2):117-130.

An intensive two-year nesting study is detailed: very low nesting success, 16.3% in 1953 and 9.4% in 1954. Predation by mammals is the principal cause of loss.

Anderson, W. 1957. A waterfowl nesting study in the Sacramento Valley, California, 1955. Calif. Fish and Game 43(1):71-90.

An extensive and detailed nesting study on 3,560 acres finds 333 nests, principally mallards; poor nesting success (38.4% hatched); and heavy predation on broods. Mammals are the principal predator. Author suggests that predator control by trapping is ineffective and recommends "judicious" poisoning.

Anderson, W. 1960. A study of waterfowl nesting in the Suisun Marshes. Calif. Fish and Game 46(2):217-226.

This estuarine marsh is found to have a perennially poor waterfowl production. Fluctuating water levels, extensive stands of tules and cattails, steep tidal slough banks, and cracks in peat soil may make this marsh incompatible with nesting and brood survival. Predators are a suggested factor.

Anderson, W. 1965. Waterfowl production in the vicinity of gull colonies. Calif. Fish and Game 51(1):5-15.

A study on a 2,000-nest gull colony near a waterfowl nesting concentration found no evidence that gulls interfered

with Canada goose production. No significant waterfowl remains were found in 95 gull stomachs. Some gull predation on ducklings was observed, but over-all losses were not considered severe. Habitat improvement suggestions are advanced.

Ballou, R. M. 1957. A brief review of Wyoming's goose restoration program. Proc. 37th Ann. Conf. W. Assoc. F. & G. Comm.:251-255.

A progress report (see Patterson and Ballou, 1953), this paper cites failures and successes of Wyoming's goose restoration program. Only one breeding flock has established from transplants. Wild-trapped goslings are best, but are difficult to obtain for transplant release. Hand-reared birds are second best, but eggs are difficult to come by; domestication of young is a problem. To counter domestication, disturb goslings minimally, release at 4 to 5 weeks, release to join other wild geese. Wyoming is also installing artificial nests, and developing marshes and islands adjacent to breeding grounds. Geese will nest in a small, undisturbed area, but they must have a large, secluded brooding area. Unfavorable factors are: fluctuating water levels, too small a starting flock, too small brooding areas, too few nest sites, overhunting, harassment, and disturbance.

Balser, D. S., H. H. Dill, and H. K. Nelson. 1968. Effect of predator reduction on waterfowl nesting success. J. Wildl. Mgt. 32(4):669-682.

A six-year study of predator control on waterfowl nesting in southwestern Minnesota (Agassiz N.W.R.) showed that controlling total predator complex led to 60% more Class I ducklings (4,400 is the projected annual figure). Annual cost was $3,000 for wages, supplies, poison, traps, etc. In six years, 1,342 raccoons, skunks, and foxes were trapped or poisoned, plus unrecorded numbers of dogs, badgers, ground squirrels, etc., plus crows, hawks, and magpies. Resident breeding population of marsh hawks was wiped out. Complete instructions are given for poisoning eggs with strychnine as predator bait. Authors recommend limited use of control measures.

Barraclough, M. E. 1954. Biology of Canada geese, Branta canadensis moffitti, in the Flathead Valley of Montana. Mont. Coop. Wildl. Res. Unit, Missoula, Mont., 91 pp.

This paper, primarily a production and mortality study, contains useful incidental notes on habitat and suggestions

for management. The author recommends purchase of inviolate breeding islands in Flathead Lake, building nest platforms on these islands, and developing muskrat marshes by impoundment where feasible. Brood rearing and gosling survival would improve if disturbance by predators and humans can be reduced. Later spring release of dammed waters to lake is recommended, to prevent flooding and swamping of goose nests. More hunting controls are also needed.

Bednarik, K. 1957. Web-footed pioneers. Ohio Cons. Bull. 21 (6):10-11, 30-32.

Reviews ways to establish new waterfowl breeding populations and analyzes reasons for success or failure. Two reasons for failure are: overcrowding and use of poor genetic strain. Better "homing" has been obtained with young birds.

Bellrose, F. C. 1959. Lead poisoning as a mortality factor in waterfowl populations. Ill. Nat. Hist. Surv. Bull. 27(3): 235-288.

A monographic treatment of the subject.

Bellrose, F. C., K. L. Johnson, and T. U. Meyers. 1964. Relative value of natural cavities and artificial nesting houses for wood ducks. J. Wildl. Mgt. 28(4):661-676.

Based on observations over a twenty-year period in Illinois, this study compares use and nesting success in natural and artificial wood duck nests; discusses predation by raccoons; describes predator foils, nesting sites, and construction of artificial nests.

Bellrose, F. C., T. G. Scott, A. S. Hawkins, and J. S. Low. 1961. Sex ratios and age ratios in North American ducks. Ill. Nat. Hist. Surv. Bull. 27(6):391-474.

This definitive study summarizes a twenty-year accumulation of data and evaluates the sex and age ratios in North American duck populations and the ways in which, in waterfowl management, these ratios can be used to measure productivity.

Bennett, L. J. 1938. The blue-winged teal, its ecology and management. Collegiate Press, Inc., Ames, Iowa.

The wetlands environment for the breeding blue-winged teal has changed drastically in the thirty years since this work was published, but the basic biology is still valid. This is still the only book devoted entirely to this species.

Bolen, E. G. 1967. Nesting boxes for black-bellied tree ducks. J. Wildl. Mgt. 31(4):794-797.

Two-year nesting box study in southern Texas showed predator-proof boxes 77% successful; unprotected nest boxes 46%; and natural cavities 44% successful. No total use figures are given due to incomplete data. Black-bellied tree ducks require larger boxes than do wood ducks. Construction details are given.

Boroff, D. A. and J. R. Reilly, 1959. Studies of the toxin of Clostridium botulinum V. Prophylactic immunization of pheasants and ducks against avian botulism. J. Bact. 77(2): 142-146.

A definitive but technically difficult paper (fifth of a series) reports on the use of toxoid (denatured toxin) to immunize young pheasants and ducks. Results are similar (save for lighter dosage) to Rosen, 1959; uses two subcutaneous injections in young birds at 3 to 4-week intervals and finds high percentage of protection.

Bossenmaier, E. F. and W. H. Marshall. 1958. Field feeding by waterfowl in southwestern Manitoba. Wildl. Soc., Wildl. Mono. No. 1, 32 pp.

Waterfowl began to prey on grain crops in Whitewater Lake region in the 1920's, when vulnerable small grains (durum wheat, barley, etc.) were first planted on a large scale. In the 1940's, when windrow-combine harvest method became common, severe waterfowl depredation again occurred. Damage varied with agricultural cycle, weather, availability of grain, waterfowl behavior, and availability of aquatic foods. Depredation controls suggested are: forced emigration, lure crops, compensation to landowners for depredation damage. Unspecified "long-range program" is recommended.

Brakhage, G. K. 1953. Migration and mortality of ducks hand-reared and wild-trapped at Delta, Manitoba. J. Wildl. Mgt. 17(4):465-477.

Analyzes 21 years of data from Delta Research Station. Determines effects of hand-rearing on the migration patterns and mortality rates of four species of wild ducks: mallard, pintail, redhead, and canvasback. Author found no major difference in migration pattern, mortality rate, departure date, and rate of progress down the flyways between wild-trapped and hand-reared birds. Homing

tendencies were similar. Mortality and vulnerability to gun pressure were higher in hand-reared than in wild-trapped ducks. The study states that, although ducks hand-reared from wild eggs are more suitable stock than game-farm birds for experimental release, the release of ducks hand-reared from wild eggs can not be recommended as a practical management technique, due to detrimental ecological factors as well as economics.

Brakhage, G. K. 1966. Tub nests for Canada geese. J. Wildl. Mgt. 30(4):851-853.

Elevated tub nests for Canada geese in Missouri eliminate flooding and most mammalian predator losses. Optimum spacing is one nest site per acre. Construction details and costs are given.

Chamberlain, J. L. 1959. Gulf Coast marsh vegetation as food of wintering waterfowl. J. Wildl. Mgt. 23(1):97-102.

Analysis of 1,251 gizzards from 17 species of waterfowl during 1955-56 and 1956-57 hunting season identified 49 plant species. Most frequently found were seeds of sawgrass, Cladium sp.; bulrush, Scirpus sp.; and spikerush, Eleocharis sp., in that order. (N.B. Occurrence of Cladium as a major food item is unique.)

Chupp, N. R. and P. D. Dalke. 1964. Waterfowl mortality in the Coeur d'Alene River Valley, Idaho. J. Wildl. Mgt. 28(4):692-702.

Mine waste contamination of river, in combination with winter and spring environmental stress, has resulted in heavy waterfowl mortality in the valley since the early 1900's. Management to alleviate the problem revolves essentially around excluding waterfowl from the valley. Since the environment is so heavily saturated with lead, zinc, and copper contaminants, there is no practicable way to clean it up.

Chura, N. J. 1962. Food availability and selective utilization by juvenile mallards (Anas platyrhynchos platyrhynchos) on the Bear River Migratory Bird Refuge, Utah. Ph.D. Thesis, Utah State Univ., Diss. Abstr. 23(7):2281.

What will young mallards eat of the wild foods that are available? Relative invertebrate abundance was sampled and correlated with plant phenology and abundance in study plots. Invertebrates were most abundant in spring through

May and then decreased, whereas plant seeds and tubers became more abundant as seasons progressed. There were many variable factors to consider in plotting food availability: water levels, habitat, previous seasons' food crops, and the conspicuousness of food items. Downy young in captivity ate 2.5 grams of food for each gram gained in body weight. Downy young (Class Ia) ducklings ate terrestrial invertebrates almost exclusively. As the mallards grew older, the proportions changed to less animal and more plant food. Class III birds were primarily vegetarians. A description of duckling feeding behavior is given. It is noted that young mallards follow their mother to feeding places but do not eat the food she does until they are Class III. Ducklings feed more heavily in morning than in afternoon.

Coburn, D. R., D. W. Metzler, and R. Treichler. 1951. A study of absorption and retention of lead in wild waterfowl in relation to clinical evidence of lead poisoning. J. Wildl. Mgt. 15(2):186-192.

Measured doses of aqueous lead nitrate were fed to adult wild mallards and clinical symptoms of lead poisoning were established. Lead deposition in tissues suggests a diagnostic tool to detect plumbism in wild ducks.

Collias, N. E. and L. R. Jahn. 1959. Social behavior and breeding success in Canada geese (Branta canadensis) confined under semi-natural conditions. Auk 76(4):478-509.

Details the breeding behavior, vocalizations, and hierarchy of captive geese on Horicon Marsh, Wisconsin.

Cooch, G. 1953. Techniques for mass capture of flightless blue and lesser snow geese. J. Wildl. Mgt. 17(4):460-465.

Large numbers (as many as 15,000) of flightless geese are herded in land drive in Northwest Territory, Canada, using Eskimo herding and trapping techniques.

Cowan, I. McT. and J. Hatter. 1953. A trap and technique for the capture of diving waterfowl. J. Wildl. Mgt. 16(4): 438-441.

Describes construction and use of a vestibule, tube net, and holding pen for receiving diving ducks herded by a drive crew. Barrow's goldeneye, bufflehead, lesser scaup, and other divers were trapped and banded in large numbers. Importance of trap placement and drive technique is emphasized.

Craig, F. R. 1950. Newcastle disease. Wildl. in N. Carolina 14(12):17-18.

Mortality in a flock of native and exotic waterfowl in Wake County, N. C., reached 85% due to Newcastle disease, a highly infectious virus. (See p. 498, Biester and Devries, 1943.)

Grider, E. D. and J. C. McDaniel. 1967. Alpha-chloralose used to capture Canada geese. J. Wildl. Mgt. 31(2):258-264.

Five blue geese and 573 Canada geese were caught with an oral-hypnotic-saturated bait. Mortality rate: 2.6% of 475 geese captured with 0.25 g of alpha-chloralose mixed with one cup of bait. Heavier dosages killed more birds. An effective capture technique, based on this drug, is described.

Day, A. M. 1944. Control of waterfowl depredations. Trans. 9th N. Am. Wildl. Conf.:281-287.

One of the opening guns in the USF&WS war on duck depredation, describes major depredation areas in 1944 and measures used to resolve the problem. Notes early depredation shoots in Imperial Valley, and publishes the first quote on that Imperial Valley lettuce grower who lost $35,000 - $40,000 in one night to widgeon.

Dickey, C. 1958. Flighting mallards on shooting preserves. Sportsmen's Svc. Bur., New York, 27 pp.

A potential recreation use of developed wetlands is the commercial shooting preserve. Tower shooting for semi-domestic mallards is explained in this pamphlet which includes diagrams of preserve layouts, ponds, pens, towers, etc. Commercial management is thoroughly discussed.

Dimmick, R. W. and W. D. Klimstra. 1964. Controlled duck hunting in Illinois. J. Wildl. Mgt. 28(4):676-688.

Compares data for 1957 through 1959 on "permit" area and "marked-blind-site" hunting system on state-owned waterfowling marshes. Advantages and inequities--economical, social, and biological--are discussed.

Durant, A. J. 1956. Impaction and pressure necrosis in Canada geese due to eating dry hulled soybeans. J. Wildl. Mgt. 20(4):399-404.

At Swan Lake Refuge, Missouri, several hundred geese died each year after field-feeding on beans shattered during harvest. After the geese watered, the ingested beans swelled and impacted the crop. Death from necrosis usually followed. Annually about 1% of the goose population of about 50,000 was affected. Management recommendations: Quit planting soybeans or cowpeas for waterfowl forage on refuge and induce neighboring ranchers to disk or plough under the shattered soybeans promptly after harvest. Ploughing under has eliminated impaction problems from refuge area.

Earl, J. P. 1950. Production of mallards on irrigated land in the Sacramento Valley, California. J. Wildl. Mgt. 14(3): 332-342.

Peak of nesting was from April 1 to mid-July. Breeding territories were located along irrigation ditches, about 70 yards of ditch per pair. Nests were located in adjacent dry grain fields; 52% of nests hatched, average hatch was 6.9. Gross production on Conaway Ranch is one bird per 2.8 acres of rice. (See Mayhew, 1955, for a study on the same area, with different results.)

East, B. 1950. The Canada goose can be brought back. Outdoor Life 105(2):38-40, 96. Feb. 1950.

The story of Canada geese transplanted to Seney National Wildlife Refuge in Michigan. An initial stocking of 300 pinioned birds in 1936 increased by 1946 to a locally raised, freely migrating population of 1,860.

Elder, W. H. and N. L. Elder. 1949. Role of the family in the formation of goose flocks. Wilson Bull. 61(3):133-140.

Authors' observations indicate that small goose flocks are usually families; that larger flocks are multiples of families rather than aggregations of individuals. Index to success of season's hatch would be counting individuals in small flocks arriving in fall migration. Study suggests that comparative analysis of small flocks before and after hunting season might reflect hunting pressure.

Elder, W. H. and M. W. Weller. 1954. Duration of fertility in the domestic mallard hen after isolation from drake. J. Wildl. Mgt. 18(4):495-502.

A three-year experiment on egg fertility determined viability of male sperm in female reproductive tract. Results are dramatically important in waterfowl management and policy implications. "If wild ducks are like tame mallards it would be quite impossible for a female abandoned by her drake to renest and lay fertile eggs without remating. . . Sex ratio disparities. . . may. . . be natural rather than induced. . . a preponderance of drakes is. . . essential to species survival."

Evans, C. D. and K. E. Black. 1956. Duck production studies on prairie potholes of South Dakota. USF&WS Spec. Sci. Rept. Wildl. No. 32, ii and 59 pp., 23 figs.

This detailed and competent study finds that all types of potholes are almost equally productive. Small temporary ponds are valuable for pairing and nesting; larger ponds are better for brooding. Vegetative data for study area are quite detailed; excellent cover maps illustrate pothole types. The report emphasizes that nesting ducks require isolation and freedom from disturbance. Cover is of secondary importance. The authors hold that current drainage programs, by eradicating the ephemeral dispersed potholes, will severely curtail waterfowl production.

Evans, R. D. and C. W. Wolfe, Jr. 1967. Waterfowl production in rainwater basin area of Nebraska. J. Wildl. Mgt. 31(4): 788-794.

Nesting studies during 1958-62 show that this area is not only important as migrating stop-over but, in wet years, is important in duck production. In wet year (1958) the 5,800-acre study area produced 816 ducklings; in dry year (1962) the same area produced none. The paper suggests wetland acquisition here, to manage and preserve these rainwater basins.

Fleming, W. B. 1955. Survey of waterfowl habitat and habitat utilization in Arizona. Ariz. G. & F. Dept. Fed. Aid Proj. W-70-R-3, WP1-Job 1. Completion Report, July 1955, 17 pp.

This Pittman-Robertson Project technical report, too detailed to summarize here, maps existing waterfowl habitat in Arizona, records waterfowl use, presents a nesting summary, and records variations in migration and population by species.

Fleming, W. B. 1959. Migratory waterfowl in Arizona. Ariz. G. & F. Dept. Wildl. Bull. No. 5, iv and 4 pp.

The field man curious about Arizona's waterfowl should start with this publication, too detailed for complete summary in this space. Waterfowl in Arizona have always been relatively scarce; channeling of rivers and the loss of their flood plains have resulted in a further sharp decline. A severe drought (1953 through 1958) has further depleted the waterfowl habitat. However, six public areas and a pattern of private developments are shaping up. Dirt stock-banks, reservoirs, and water projects all have waterfowl habitat potential--if planned for. There is little private incentive. In 1959 the author knew of only five private duck clubs in Arizona. Many small private ponds and marshes exist, but many are never hunted; fewer are managed to produce or sustain waterfowl.

Foley, D. D., D. Benson, L. W. DeGraff, and E. R. Holm. 1961. Waterfowl stocking in New York. New York F. & G. J. 8(1): 37-48.

Wild-strain mallards were stocked in New York from 1939 to 1942; larger scale stocking, beginning in 1946, went on until 1952. There is controversy whether the stocking or natural fluctuation was responsible for the slight upsurge in New York mallard population. This paper details differences between "New York strain" mallards and "wild" mallards, and presents band return data, mortality rates, etc. The New York Department of Fish and Game discontinued the mallard program in 1952, as a pump-priming successfully completed, and turned to the stocking of other species: pintail, gadwall, redheads, and canvasback.

Geib, J. R. 1956. Home grown ducks. Colo. Outdoors 5(4):2-7.

Lists eight major waterfowl production areas located in Colorado: Brown's Park, North Park, Yampa Valley, White River Plateau, Poudre Valley, South Platte Valley, South Park, and San Luis Valley. Author states that, in a normal year, Colorado produces 100,000 ducklings, "...considerably less than we harvest each year, (but) it is still a contribution to the Central Flyway waterfowl population."

Geib, J. R., M. G. Sheldon, and D. J. Neff. 1961. The nesting Canada geese of Moffat County, Colorado. Proc. 45st Ann. Conf. W. Assoc. F. & G. Comm.:136-146.

Colorado Waterfowl Project, alarmed by a decline in production of Utah-Imperial sub-flock of Great Basin honkers,

studied for three years (1956-1959) the breeding grounds in Moffat County's Yampa and Green River drainages. Geese were censused by counts during a series of downriver float trips. Population, habitat, and mortality data obtained showed that in dry years geese had good success. Flooding was the major cause of loss. Favored nest sites along river course were low, grassy islands (those most subject to destructive flooding). Visibility was found to be a factor in nest site preference. Beavers were found not only compatible but advantageous to goose production; these mammals cleared islands of willow and other brush and so created favored nest sites. Authors recommend maintaining large beaver population along rivers; clearing brush and willows from points and favored sites on islands; building artificial nest platforms. It has been found that only those nest platforms located on river islands are used; these are well accepted.

Girard, G. L. 1939. Notes on the life history of the shoveler. Trans. 4th N. Am. Wildl. Conf.:364-371.

Discusses observations in 1937 on 132 shoveler duck nests found in new habitat developed on Nine-Pipe and Pablo Migratory Bird Refuges in Lake Co., western Montana. Although the paper has very little information on management, it is of historical interest to a worker in the same area today.

Girard, G. L. 1941. The mallard; its management in western Montana. J. Wildl. Mgt. 5(3):233-259.

A three-year ecological study of mallards in western Montana, on two 2,000-acre refuges, where management was considered a year 'round problem although resident nesting was emphasized. Production was heaviest on grassy shorelines bordering small ponds. Favored nesting areas were small protected bays or, in larger water bodies, peninsulas and islands. Natural feed was scarce during eight months of the year, farms provided the bulk of forage. Paper covers wide range of topics: behavior, management, and characteristics of nesting and migrating birds. Hunting and farming programs are discussed.

Glover, F. A. 1968. Waterfowl of Colorado. Part I. Colo. Outdoors 17(5):28-44.

First of a three-part series on identification, management, and habitats of Colorado waterfowl, directed mainly to the informed layman. Part I contains four color plates and

line drawings of 18 species (adult pair), with brief description and field marks. Breeding habitats, food, and importance to Colorado of each species are summarized.

Glover, F. A. 1968. Waterfowl of Colorado. Part II. Colo. Outdoors 17(6):17-24.

This section on management is largely generalities, save for three tables on Colorado's waterfowl banding (1960-66), duck stamp sales (1956-67), and waterfowl winter census (1968) by location in the state. Appended is a list of federal waterfowl legislation: Lacey Act (1900), Migratory Bird Treaty (1916-18), Migratory Bird Conservation Act (1929), Migratory Bird Hunting Stamp Act (1934), Migratory Bird Treaty Act Extension (1937), Federal Aid to Wildlife Restoration Act (1937), Wetlands Loan Act (1961), Wetlands Loan Act Amended (1967).

Glover, F. A. 1969. Waterfowl of Colorado. Part III. Colo. Outdoors 18(1):31-37.

Part III gives a very general account of eleven food and cover plants found in Colorado: sago pondweed, bulrush, bur-reed, arrowhead, cattail, spike rush, widgeon grass, duckweed, wild millet, smartweed, and sedge. No scientific names are given. However, line illustrations by Alkire are excellent.

Gollop, J. B. 1965. Dispersal and annual survival of the mallard (Anas platyrhynchos). Ph.D. Thesis, Univ. Saskatchewan, Diss. Abstr. 27(5):1654-B.

Although an excellent and definitive study, this paper has only slight and general pertinence to wetlands ecology. In 1954-59 in Saskatchewan, Canada, 12,962 flightless young mallards were banded. Dispersal and survival data were derived from band returns: 30% returns from Canada; Mississippi Flyway 56%; Central 36%; Pacific 6%; Atlantic 1%. Other results: origin of birds rather than their location at time of migration apparently determined their migration route. Young mallards and adult females from same water areas showed wide dispersal. Ducklings from same brood appeared to separate in migration. Recoveries indicate that a mallard hen in Kindersley District, Sask. (origin point of study) had to lay an average of 8.5 eggs to maintain the population.

Grandy, J. W., L. N. Locke, and G. E. Bagley. 1968. Relative toxicity of lead and five proposed substitute shot types to pen-reared mallards. J. Wildl. Mgt. 32(3):483-488.

Results of a 30-day toxicity test of shot ingested by waterfowl: commercial lead shot--100% fatal; lead-tin alloy--27% fatal; zinc--20% fatal, 80% severely distressing; tin, nickel, or teflon-coated steel--0.0% fatal.

Grange, W. 1935. Handling wild mallards in captivity. Game Breeder and Sportsman 39(8):210-211.

Discusses the importance of selection, managing small groups rather than flocks, and conditioning in natural environment to insure wild and gamy birds.

Griffith, R. 1948. Improving waterfowl habitat. Trans. 13th N. Am. Wildl. Conf.:609-618.

A very general paper on techniques of improving or developing wetlands for waterfowl. Mainly concerned with nesting, the paper contains few specifics and no real information.

Hanson, H. C. 1965. The giant Canada goose. So. Ill. Univ. Press, xxiii and 226 pp.

In this detailed account the author relates his rediscovery of populations of the supposedly extinct giant Canada goose (Branta canadensis maxima) and advances the thesis "that present-day stocks of large Canada geese that now nest in the midsector of the Continent east of the Rocky Mountains constitute a single recognizable race and are in no way distinguishable from stocks that bred in the region at the time of early settlement." Detailed biological and ecological evidence is presented.

Hartung, R. 1964. Some effects of oils on waterfowl. Ph.D. Thesis, Univ. Mich., Diss. Abstr. 25(12, Pt. 1):6866.

This study examines the physiological mechanisms by which oil pollution damages waterfowl. External oiling results in loss of buoyancy and insulation; the birds drown or chill. Chilling is not, in itself, lethal but death occurs after exhaustion of body fat deposits. Oiling separates birds from their food supply; the concurrent high demands for metabolic energy greatly accelerate starvation. Ducks ingest significant amounts of oil while trying to clean their feathers of the pollutant. Their behavior is abnormal and their activity is reduced. Oil ingestion

causes a high incidence of lipid pneumonia in ducks. Many oils irritate the gastro-intestinal tract. Ingested oils affect functions of the pancreas, liver, and kidneys. Oils deter reproduction, ingested oil inhibits egg-laying. Eggs incubated by oiled ducks fail to hatch. Experiments in incubators show that 12.5 mg of oil per egg inhibits hatching. The paper concludes by stating that oils sedimented to bottom are able to partition other organic chemicals from the water.

Hawkins, A. S. and F. C. Bellrose. 1940. Wood duck habitat management in Illinois. Trans. 5th N. Am. Wildl. Conf.: 392-395.

Wood duck boxes--some of the earliest work.

Herman, C. M. 1951. Blood parasites from California ducks and geese. J. Parasitology 37(3):280-282.

First report of mosquito-borne malaria in native North American ducks.

Hochbaum, H. A. 1942. Sex and age determination of waterfowl by cloacal examination. Trans. 7th N. Am. Wildl. Conf.: 299-307.

This is the original write-up of a standard technique now used by field men. Quoted and illustrated in "Ducks, Geese and Swans of North America" by Kortright.

Hochbaum, H. A. 1944. The canvasback on a prairie marsh. Am. Wildl. Inst., 201 pp.

This 25-year-old classic remains the definitive work on the species and on pothole country waterfowl management. Although definitely not a text on wetlands management, this is an easily read book filled with useful information and is recommended for every professional library.

Holm, E. R. and R. J. Bauer. 1959. Potentialities of certain species of waterfowl for mass production. New York F. & G. J. 6(1):1-45.

This detailed paper recounts pioneer work in the incubation of wild-collected duck eggs, rearing ducklings, and releasing them to managed wild locations. Describes minutiae of incubation, rearing, behavior, propagation with wild pairs, artificial nest structures, etc. Pintail, gadwall, redheads, and canvasback produced substantial numbers of eggs in captivity. These eggs can be successfully hatched,

and the ducklings reared and maintained over winter. Care must be taken not to hybridize or otherwise dilute the genetic pattern of each species.

Hunt, E. G. and W. Anderson. 1966. Renesting of ducks at Mountain Meadows, Lassen County, California. Calif. Fish and Game 52(1):17-27.

One hundred and ten ducks were captured on nest, banded, colormarked, and released. Their eggs were removed. Nineteen ducks renested, 4 renested twice, 1 renested a third time.

Hunt, E. G. and A. E. Naylor. 1955. Nesting studies of ducks and coots in Honey Lake Valley. Calif. Fish and Game 41 (4):295-314.

A two-year study in the Great Basin country of northern California reports on 202 duck and 20 coot nests found in 1951; and on 359 duck and 143 coot nests found in 1953. Nesting success was high both years; major losses were due to predation. Nest sites and vegetation are described; nest and brood history presented.

Hunt, R. A., L. R. Jahn, R. C. Hopkins, and H. G. Amelong. 1958. An evaluation of artificial mallard propagation in Wisconsin. Wisc. Cons. Dept. Tech. Wildl. Bull. No. 16, 79 pp.

Mallards, at a cost of $2.04 per bird, were hand-reared to the age of four weeks and then released into the wild. All birds were banded and 27% of bands were recovered; 94% of these were shot the first year, most within 20 miles of release point. Recovery percentage is judged to be the same as in banded wild birds. The writers estimate that, to raise Wisconsin duck kill by 10%, about 155,000 mallards must be released annually; they suggest that it is better economy to improve and extend waterfowl habitat.

Jahn, J. R. 1965. Duck and coot ecology and management in Wisconsin. Ph.D. Thesis, Univ. Wisc., Diss. Abstr. 26(7):3566.

A general account of population management, hunting, etc. Little practical wetlands information.

Jones, J. C. 1940. Food habits of the American coot with notes on distribution. USF&WS (U. S. Bur. Biol. Surv. in 1940) Wildl. Res. Bull. 2, 52 pp.

The lowly mudhen, Fulica americana, has been so slightly regarded by waterfowl biologists that this 30-year-old U. S. Biological Survey research bulletin is still the most complete and definitive work on this ubiquitous water bird. Primarily a food habits investigation based on 801 stomachs collected throughout the coot's range, this study finds a 90% vegetarian diet of wide variety. Description, habits, and distribution of the coot are discussed; incidents of crop depredation are cited, usually local and only occasionally serious.

Jones, R. E. and A. S. Leopold. 1967. Nesting interference in a dense population of wood ducks. J. Wildl. Mgt. 31(2): 221-228.

Erecting nest boxes along a slough in Sacramento Valley, California, has resulted in a breeding colony of wood ducks that has increased faster than boxes can be put up. Nesting interference, compound nesting, desertion, and inefficient production are attributed to housing shortage. Lack of territorial defense by established pairs is primarily responsible for nesting inefficiency in this high-density population.

Jordan, J. S. 1953. Consumption of cereal grains by migratory waterfowl. J. Wildl. Mgt. 17(2):120-123.

Waterfowl were held in captivity and fed a diet of cereal grains. Data are based on average daily food intake, by seasons. Consumption varied with weather; birds ate more during cold weather. Mallards averaged 0.16 lbs. of small grain or 0.13 lbs. of corn per day; in cold weather 0.18 lbs. of small grain or 0.16 lbs. of corn. Canada geese averaged 0.36 lbs. of small grain or 0.40 lbs. of corn per day. Bluewinged teal consumed 0.06 lbs. of mixed grain per day.

Jordan, J. S. 1953. Effects of starvation on wild mallards. J. Wildl. Mgt. 17(3):304-311.

Physiological effects of starvation on captive wild mallards were studied. Conclusion: two weeks or less of complete starvation is not fatal to free wild mallards during normal winter weather. Beyond this point, mortality will rise rapidly and in 30 days heavy losses can be expected.

Kalmbach, E. R. 1938. A comparative study of nesting waterfowl on the Lower Souris Refuge: 1936-1937. Trans. 3rd N. Am. Wildl. Conf. 3:610-623.

Of historical interest--principally concerned with predation on nesting waterfowl.

Kalmbach, E. R. 1968. Type C botulism among wild birds--a historical sketch. USF&WS Spec. Sci. Rept. Wildl. No. 110, 8 pp.

"Western duck sickness" was first reported in 1910. Great numbers of waterfowl and other wildlife have been lost to this disease which first was thought to be "alkali poisoning" but is now known to result from the toxin of Clostridium botulinum, Type C. History of the incidence and of the research is given, plus 32 references.

King, C. L. 1953. Oil sumps--duck nemesis. Wyoming Wildlife 17(11):32-33.

Oil sumps are small ponds of oily water resulting from oil field operations. Emulsified oil gradually rises to form scum on top of the water. In Big Horn Drainage Basin, 914 dead birds (90% of these dabbling ducks) were found dead in sumps in 1951-1952. Oil is periodically burned from sumps, sumps are treated chemically. Scare devices, rattling tin wired over sumps, are used to flare birds.

Korschgen, L. 1955. The fall food habits of waterfowl in Missouri. Mo. Cons. Comm. P-R Report 14, 41 pp.

A total of 2,252 gizzards from 17 species of ducks, and 184 samples from Canada geese, determined the principal foods, lead shot incidence, changing trends in waterfowl food habits, and the value of propagated duck foods on waterfowl areas in Missouri. No major trend change was noted. Lead shot incidence was 4.2% in puddle ducks and 6.1% in divers. Use pattern in food was due to availability; preference had little weight. The presently propagated food plants--wild millet, Japanese millet, smartweeds, etc.--were well represented in gizzards. No change in Commission recommendations for food plant propagation is anticipated.

Kossack, C. W. 1950. Breeding habits of Canada geese under refuge conditions. Am. Midl. Nat. 43(3):627-649.

Two hundred-fifty birds bred in semi-wild are observed on a private refuge in Illinois.

Lokemoen, J. T. 1966. Breeding ecology of the redhead duck in western Montana. J. Wildl. Mgt. 30(4):668-681.

Two-year nesting study in pothole country of western Montana finds redhead ducks' breeding density is 25 pairs per square mile, but nesting success is only 15% due to parasitism and communal nesting. Degenerate nesting behavior is perhaps abetted by habitat deficiencies. Management suggestions: connected potholes, supplied from central water source and with controlled water levels.

Madson, J. 1960. The mallard. Olin-Mathieson Chem. Corp., 80 pp., illus.

This booklet is primarily for the layman, but has general interest for the field biologist. Chapter titles are: History, Parasites and Diseases, Management, Hunting, Man and Mallard.

Mayhew, W. W. 1955. Spring rainfall in relation to mallard production in the Sacramento Valley, California. J. Wildl. Mgt. 19(1):36-47.

Mayhew repeated a study by Earl (1950) a year later on the same area and obtained very different results. Mayhew, then, accumulated data on rainfall and humidity and found a correlation with yearly duckling production, although nesting numbers in this area vary little from wet year to dry year. Tests on incubating mallard eggs with varying humidities correlated with hatching. Conclusion: direct application of water to egg is necessary to hatch.

McFarland, L. A., H. George, and H. McKinnie. 1963. Grain preference of captive waterfowl. Calif. Fish and Game 49(3):207-209.

Twenty-seven captive ducks and geese provided grains ad libidum preferred watergrass to all others tested. Second choice was Purina Hen Chow, followed by sudangrass, reed canarygrass, whole barley, alkali bulrush, and smartweed. Average consumption was 64 grams per day.

McGinnes, B. S. and R. A. Beck. 1953. Recuperative rate of wingshot mallard. J. Wildl. Mgt. 17(4):541-542.

Three wing-shot ducks with broken humeri and protruding bones recovered to near flight in three months.

McLean, D. D. 1946. Duck disease at Tulare Lake. Calif. Fish and Game 32(2):71-80.

A summary of the waterfowl populations and incidence of botulism for 1937 through 1944. This 20-year-old study, excellent in its day, is now primarily important for its historical information concerning size and species composition of local waterfowl concentrations.

Meanley, B. and A. G. Meanley. 1958. Nesting habitat of the black bellied tree duck in Texas. Wilson Bull. 70(1):94-95.

Ten black bellied tree duck nests in the lower Rio Grande Valley, Texas, were found and described. All nests were located in hollow trees near a small lake. Eight nests were in ebony and two in hackberry trees. Nest cavities were in main trunk; the entrance hole seldom over 3 or 4 feet from the ground. The site was usually in a brushy thicket.

Mendall, H. L. 1949. Food habits in relation to black duck management in Maine. J. Wildl. Mgt. 13(1):64-101.

This food habits study is a part of an eight-year research project. Stomachs, collected during all seasons, numbered 605. Bulrush seeds accounted for more than 30% of the diet. Four factors influence food habits: water levels, food abundance, preference, and hunting pressure. Black duck depredation on crops or fisheries was negligible. Management recommendations: stabilizing water levels and planting of preferred seasonal foods.

Miller, A. W. and B. D. Collins. 1954. A nesting study of ducks and coots on Tule Lake and Lower Klamath National Wildlife Refuge. Calif. Fish and Game 40(1):17-37.

A study of 826 ducks nests and 154 coot nests, in 1952, showed high fertility and nesting success; 3,837 brood counts show that major losses occur in first week of life and thereafter brood size is fairly stable; 92% of all nests were within 50 yards of water. Nesting habitat preferences by species are detailed.

Naylor, A. E. 1953. Production of the Canada goose on Honey Lake Refuge, Lassen County, California. Calif. Fish and Game 39(1):83-94.

Great Basin Canada geese, on 360 nests, produced 1,904 eggs in 1951; 68.3% of nests were successful. Hatching success of eggs was 82.6%. Seventeen different cover types are

used for nesting. Tules, islands, and ditch banks are preferred. Management recommendations: nesting islands, pre-season predator control, weed control.

Naylor, A. E. 1960. The wood duck in California with special reference to the use of nest boxes. Calif. Fish and Game 46(3):241-269.

In a five-year study, 152 boxes were installed in various habitats in central California; 42% were used annually by wood ducks; 76% of nests hatched successfully. Depredation losses were light. Twelve other animal species occupied 31% of the boxes. Sparrow hawks, honey bees, and screech owls were the most common nest box invaders. Regular maintenance was necessary to keep the boxes functional. Vandalism, infestation by bees, flooding, and splitting were the major maintenance problems.

Naylor, A. E. 1962. Wood ducks and nest boxes. Calif. Dept. F. & G. Game Mgt. Leafl. No. 6, 8 pp., 1 diagram, 6 photos.

This "how to" booklet gives precise construction details and diagrams for wooden nest boxes. Instructions include site selection (box must be visible to flying wood duck), installation, nesting material, maintenance, use by other animals, and a list of do's and don't's. This leaflet is based on earlier (1960) research by the same author.

Neff, J. A. 1955. Outbreak of aspergillosis in mallards. J. Wildl. Mgt. 19(3):415-416.

In January 1949, on two lakes kept open by steam plant operation near Boulder, Colorado, wintering waterfowl began to die of aspergillosis. Estimated losses were about 1,000 from a population of 50,000. The epizootic was traced to moldy ensilage scattered on top of the snow. Ducks had fed on this ensilage. Many of the dead waterfowl appeared in excellent condition, fat and heavy.

Odin, C. R. 1957. California gull predation on waterfowl. Auk 74(2):185-201.

A waterfowl nesting study in Utah's Farmington Bay finds severe depredation by California gulls on waterfowl nests--18.3% of eggs in 317 nests were destroyed by these predators. A "rational" control program is recommended.

Olson, D. P. 1964. A study of canvasback and redhead breeding populations, nesting habitats, and productivity. Ph.D. Thesis, Univ. Minn., Diss. Abstr. 26(2):597.

Breeding populations of canvasback and redhead ducks were studied during three seasons (1959-1961) on different habitat types (marshes, lakes, potholes) in southwestern Manitoba. Conclusions: the sex ratio of canvasbacks observed on potholes in first two weeks of June is an index of forthcoming productivity in this and other waterfowl species. Parasitism of canvasback nests by redheads is a serious detriment to canvasback where redheads outnumber them. Where canvasback outnumber redheads, redhead productivity is increased but total canvasback productivity is scarcely affected by parasitism. Draining of small water areas (preferred canvasback habitat) is thus detrimental even if large ponded areas remain. Management implication: low ratio of redheads to canvasback, insured by development of numerous small areas, assured maximum productivity by both waterfowl species.

Oring, L. W. 1964. Behavior and ecology of certain ducks during the postbreeding period. J. Wildl. Mgt. 28(2):223-233.

This is one of the few accounts in the literature of the social behavior of waterfowl during the flightless period of their postbreeding moult. Thirteen species of ducks were observed.

Oring, L. W. 1966. Breeding biology and moults of the gadwall, Anas strepera Linnaeus. Ph.D. Thesis, Univ. Okla., Diss. Abstr. 26(11):6928.

"Gadwalls arrived and bred about three weeks later in southern Manitoba in 1963-64 than they do in northern Utah. Nest sites were usually on dry ground and near water. Clutches were larger in wild than in captivity, and first clutches were larger than re-nest clutches. Incubation periods were shorter in hatchery than they were out-of-doors. In the wild 46% of 30 nests were successful, 37% were depredated, and 17% were deserted..." Balance of dissertation is concerned with contrasting captive and wild gadwall pair bond behavior, moults, feathering, and other biological minutiae.

Patterson, R. L. and R. M. Ballou. 1953. Status of the Canada goose in Wyoming. Proc. 33rd Ann. Conf. W. Assoc. F. & G. Comm.:194-200.

Canada geese breed in Wyoming mainly on the western slopes and Great Basin drainages. The breeding ground inventory in 1953 totaled 1,900 birds, but the authors feel that the breeding population, on a revised estimate, totaled 670. Heaviest concentrations (of river-nesting geese) are on middle and lower sections of streams, below 7,000 ft. elevation. Snow is a factor, but hot springs (Yellowstone and Snake River) may counteract deep snow effect. Artificial nest platforms, habitat development, incubation of eggs, rearing and release of goslings, and protection from predation and overhunting are discussed in general terms.

Preston, F. W. 1957. The look-out perch as a factor in predation by crows. Wilson Bull. 69(4):368-370.

A local flock of semi-domestic mallards fails to propagate because crows watch duck movements, seek out the nests, and destroy the eggs, particularly when spring cover is low. Re-nesting in heavier cover is slightly more successful. The crows use trees, poles, and other elevated sites as look-out perches. The author suggests this nesting failure explains why mallards prefer to nest in treeless prairies. Management suggestion: remove any potential perch within ½ mile of duck nest.

Quotrup, E. R. and R. L. Sudheimer. 1942. Research notes on botulism in western marsh areas with recommendations for control. Trans. 7th N. Am. Wildl. Conf.:284-293.

Earliest definitive work on the subject.

Rearden, J. D. 1951. Identification of waterfowl nest predators. J. Wildl. Mgt. 15(4):386-395.

Diagnostic characteristics of nest predators: Raccoons--paw out nest contents, lengthwise half-shell fragments frequently found, raccoon hair usually found. Mink--tiny tooth-marks on unbroken portion of shell, mink hair usually found, nest is seldom disarranged. Skunk--nest demolished, eggs crushed whole at one bite and the contents sucked out, skunk hair usually found, skunky odor detected. Red fox--eggs are usually removed and nest is often left undisturbed; red foxes seldom raid nests in a wet marsh, often steal only one or two eggs and eat them away from nest; fox hair

usually found. Crow--nest usually left undisturbed or only slightly disarranged, parts of egg shells are left but the remains of all eggs can not be accounted for; crows usually fly to perch to eat the eggs; often more than one crow is involved in a raid; egg usually retains spherical shape with a moderate or large opening in side; generally there is a smaller puncture, just below and to one side of the larger opening caused by the crow's lower mandible.

Rienecker, W. C. and W. Anderson. 1960. A waterfowl nesting study on Tule Lake and Lower Klamath National Wildlife Refuges, 1957. Calif. Fish and Game 46(4):481-506.

At five-year intervals the California Department of Fish and Game conducts nesting studies on major waterfowl areas in California. This second study is a detailed work assessing 1,151 duck nests and 276 goose nests. Much ecological information on Great Basin waterfowl habitat is presented in this major paper.

Rogers, J. P. 1964. Effect of drouth on reproduction of the lesser scaup. J. Wildl. Mgt. 28(2):213-222.

Nesting studies on lesser scaup during drouth of 1959 and 1960 show that poor habitat inhibits nesting. Inhibition was checked by physiological examination of ducks, which showed low ovarian weights and follicular atresia. Scaup are especially vulnerable to predation because of their late nesting and choice of water's edge as nesting site. Scaup seldom re-nest.

Rogers, J. P. and L. T. Korschgen. 1966. Foods of lesser scaups on breeding, migration, and wintering areas. J. Wildl. Mgt. 30(2):258-263.

Stomach contents of 164 lesser scaups (Aythya affinis) collected in Manitoba, on the Mississippi River, and along the Louisiana coast, are analyzed. Animal foods make up bulk of the diet. Most important are amphipods on breeding area, mollusks in fall concentrations along the Mississippi, and fishes on the Gulf Coast in winter. These findings refute earlier studies which show lesser scaup as chiefly vegetarian. Greater and lesser scaup feeding patterns are very similar, but differ sharply from other Aythya which are mainly vegetarians.

Rosen, M. N. 1959. Immunization of pheasants with botulinum toxoid. Calif. Fish and Game 45(4):343-350.

The findings in this paper will apply to waterfowl. Two subcutaneous injections of Clostridium botulinum Type C

toxoid (denatured toxin) developed protection against botulism in pheasants. Use of one product reduced mortality to 4.7%, another product to 7.8%; mortality was 17% in control group (unprotected). This work agrees with Boroff and Reilly (1959) that two injections of toxoid were optimum; disagrees on dosage (0.5 ml or 1.0 ml). Chicks were inoculated at 3-4 week intervals. The toxoid used was a commercial product developed for use by mink ranchers.

Rosen, M. N. 1965. Control of waterfowl botulism. Calif. Dept. F. & G. Game Mgt. Leafl. No. 10, 6 pp.

A management leaflet directed to the layman or field worker, telling what botulism is, when and how the toxin affects the ducks, and what to do about prevention or cure. Gross symptoms are described: "limberneck" and nictitating eyelid paralysis, inability to fly and to move, greenish diarrhea followed by vent plugging. Treatment of sick birds by pick-up, hospitalization, anti-toxin and/or fresh water is discussed. Denying affected areas by herding or harassing devices is mentioned. Preventive land and water management measures are suggested. The author cites the necessity of adequate water level controls.

Rosen, M. N. and R. A. Bankowski. 1960. Diagnostic technic and treatment for lead poisoning in swans. Calif. Fish and Game 46(1):81-89.

Waterfowl get lead poisoning from ingested lead shot but accurate field diagnosis, in the presence of other possible diseases, is difficult. Diagnostic techniques and treatment for swans are reviewed. Injection of calcium versenate, a chelating agent, results in dramatic temporary recovery. Techniques to remove lead pellets from swan gizzards are described. As preventive management, the authors suggest stockpiling bird grit accessible to feeding waterfowl in grit-free areas, such as Tule Lake Refuge.

Rutherford, W. H. 1965. The Canada geese of Larimer County. Colorado Outdoors 14(2):16-19.

Surplus goslings and eggs of Great Basin honkers, Branta canadensis moffitti, semi-domesticated during the 1930's near Denver, were transplanted to Fort Collins and released on protected college lake in 1957. Nesting platforms were built and other management measures were taken. No artificially reared goslings have been released since 1962. Geese nested well locally in 1963-64. Goose population is now grown to a size justifying modification of local

closure. Larimer County geese are reportedly contributing to open areas' bags. Migrant geese are apparently attracted to winter over. Surplus honkers from Denver area are now being released elsewhere in Colorado, as a result of this successful project.

Ryder, R. A. 1961. Coot and duck productivity in northern Utah. Trans. 26th N. Am. Wildl. Conf.:134-147.

Management implications of this two-year nesting study are: 1. Increased duck production might result from cattail control plus planting of desirable emergent food and cover. 2. Small ditches cut through saltgrass flats will provide spoil banks for loafing, nest cover and water for nesting ducks, without increasing coot nesting habitat. 3. Predator control is needed, particularly along dikes. 4. A continual promotional campaign to hunt coots is needed.

Sharp, W. M. 1951. Observations on predator-prey relations between wild ducks, trumpeter swans, and golden eagles. J. Wildl. Mgt. 15(2):224-226.

At Red Rock Lakes, Montana, a pair of golden eagles wintered over from 1944-1947, and ate three ducks a week, killed a few cygnets one year, and "stimulated unrest" among the ducks and swans (and observing biologists) until a "well-placed rifle shot broke up the pair" and the surviving eagle vacated.

Sherwood, G. A. 1966. Canada geese of the Seney National Wildlife Refuge. Ph.D. Thesis, Utah State Univ., Diss. Abstr. 27(8):2926-B.

Thirty years after a spectacularly successful transplant and population upsurge, the Seney Canada goose population began to decline. Study found several causes: a massive die-off from Leucocytozoon cost 500 goslings; in 1954 coyote and raccoon depredation on nests, eggs, goslings, and even adult geese was severe. Significant observations were made of pairing and other aspects of behavior. Recommendations for goose management on the Seney Refuge were presented.

Sipple, G. W. 1953. Avian botulism: information on earlier research. USF&WS. Spec. Sci. Report. Wildl. No. 23, 11 pp.

Reports on history and research in avian botulism up to 1953. Some of the preventive and remedial measures have been superseded.

Sizer, B. 1967. The saga of Clyde Goose. Ariz. Wildl. Sportsman 39(12):18.

In 1965-66, Arizona Fish and Game Department transplanted honkers to areas where geese had never bred. Released goslings have grown up, paired, and attempted to nest in refuge at Big Lake, Arizona. Experimental transplants are still under study.

Smith, D. A. 1958. An economic evaluation of selected treatments for avian botulism on Utah marshes. Proc. 38th Ann. Conf. W. Assoc. F. & G. Comm.:220-225.

This economic evaluation is based on 2,214 ducks treated during study. Class I (flightless but ambulatory) should be left in the field; Class II (paralyzed, unable to move on flat surface) should be field-inoculated with 2 cc polyvalent antitoxin; Class III (prostrate, severely stricken) should be transported to the hospital for inoculation and confinement in a fresh water pond. Thin Class I birds had better recovery rate than fat Class I's. Fat was an asset to Class II and Class III; however, body condition in botulism poisoning does not reflect degree of bird's affliction. Tables showing cost per bird as of 1953-54 are presented, but would not be realistic in 1969.

Smith, R. H. 1952. More ducks for eastern Montana. Montana Wildlife 2(3):10-11.

Reviews duck occurrence and breeding in artificial ponds. The ponds studied averaged 3.2 acres. Seven species of puddle ducks bred, averaged 1.7 broods per pond, brood size at flight averaged 5. Total production per pond averaged 9 ducks, or about 2 ducks per square mile. Very small ponds did not have broods. Overgrazed shorelines produced few waterfowl.

Smith, R. H. 1953. A study of waterfowl production on artificial reservoirs in eastern Montana. J. Wildl. Mgt. 17(3): 276-291.

A three-year study on 124 artificial reservoirs of five different types (sagebrush-grassland, marsh, meadow, woody, open) located in semi-arid sagebrush or grassland prairie. Most reservoirs were used for livestock watering. Average size of 124 ponds was 3.2 acres; over half were 2 acres or less. The mean age of 88 reservoirs was 8.2 (1-18) years. Vegetative densities are given. Twelve

species of ducks used the reservoirs; mallard, pintail, and blue-winged teal were predominant by far. No broods of diving ducks were seen. Production was generally light--22 nests discovered in three summers--but over 70% of the nests were successful. The author finds that, generally, the larger the pond the greater the usage, but since few of his study ponds were over ten acres the reservoirs can still be classed as relatively small.

Smith, R. H. and A. S. Hawkins. 1948. Appraising waterfowl breeding populations. Trans. 13th N. Am. Wildl. Conf.: 57-62.

Describes aerial census methods and notes categories of ecological land-types censused in breeding ground surveys. Stresses that indices rather than total counts are the goal.

Southwick, C. 1953. A system of age classification for field studies of waterfowl broods. J. Wildl. Mgt. 17(1):1-8.

Formulates a practical system of age classification for waterfowl broods, based on a knowledge of growth and plumage development in hand-reared birds. Eight species of ducks are studied; comparative growth weights and plumage development are recorded. The author identifies five discrete age classes: I(a), early downy; I(b), late downy; II(a), predominantly downy with noticeable feathers; II(b), predominantly feathered with noticeable down; III, completely feathered prior to flight.

Sowls, L. K. 1955. Prairie ducks; a study of their behavior, ecology and management. Stackpole Co. and Wildl. Mgt. Inst., 193 pp.

Based on a four-year study (1946-1950), this book presents detailed information on the nesting and homing behavior of five species of surface-feeding ducks. Most of the data were collected on a study area of 3,115 acres in the Delta marsh, southern Manitoba. Chapter V, on the nesting terrain, is probably of most interest to wetlands ecology.

Sperry, C. C. 1947. Botulism control by water manipulation. Trans. 12th N. Am. Wildl. Conf.:228-232.

Studies on Bear River Refuge, Utah, in 1943 and 1946, found that botulism losses increased if damp mud flats were submerged. The losses decreased with progressive lowering of water on exposed lake bottoms. The ability to drain ponds rapidly and completely was an important control measure.

Stollberg, B. P. 1949. Competition of American coots and shoalwater ducks for food. J. Wildl. Mgt. 13(4):423-424.

Brief report finds no important competition for food between coots and shoalwater ducks at Horicon during period studied; 90% of coot diet was duckweed. Since this plant shades out higher valued pondweeds, coot feeding habits probably benefit Horicon ducks.

Stollberg, B. P. 1950. Food habits of shoalwater ducks on Horicon Marsh, Wisconsin. J. Wildl. Mgt. 14(2):214-217.

Hunting pressure, food availability, bird cruising range, and dormant seeds must be considered in establishing palatability ratings for duck food. Bulrush seed was the most important spring and fall food, with insect larvae, bur-reed, duckweed, sedge, spikerush, and water plantain being used as substitute feed. Most of the wild rice was removed by blackbirds early in the fall. Sedges, although common, were useless as duck food in the fall and spring.

Tinker, F. A. 1958. Avian botulism - the battle at Bear River. Audubon Mag. 60(3):116-119, 140, 5 photos. 60(4):174-177, 6 photos. 60(5):224-227, 7 photos.

A popular account, in three parts, of waterfowl botulism, its history, prevention, and treatment. This article contains good photos and solid information.

USF&WS. 1958. The restoration of breeding Canada goose populations on National Wildlife Refuges. USF&WS, Branch Wildl. Ref., Wildl. Mgt. Ser. Leafl. No. 15, ii and 21 pp., 2 figs.

This comprehensive "how to" pamphlet gives the history and reasons for past failures and successes, and discusses planning and construction of enclosures; where, when, and how to obtain starting stock; care and management of goose flock; goose behavior and feeding; predator control; confining, wing clipping, pinioning, and brailing. The use of a brail is illustrated.

Vaught, R. W. and L. M. Kirsch. 1966. Canada geese of the eastern prairie population, with special reference to the Swan Lake flock. Mo. Dept. Cons. Tech. Bull. 3:XIII, 91 pp.

The Swan Lake NWMA goose flock had 800 birds in 1941 and by 1955, at the peak of migration, had a population of 133,000 Canada geese. In 1941, 41,500 Canada geese wintered

in Swan Lake. This bulletin, while emphasizing life history data for the flock, presents many details on refuge management. Grains and clovers are annually planted if flood conditions (from Grand River) permit. Refuge impoundments, populated by carp, catfish, and other rough fish species, are too turbid to produce submergent aquatic plants. Summer drawdowns are used to produce wild millet, rice cutgrass, chufa, smartweeds, and other annuals on exposed mudflats. As much as 3,000 acres of such food and cover are produced in non-flood years. The mudflats are inundated in fall for the waterfowl season.

Weigand, J. P., M. J. Pollock, and G. A. Petrides. 1968. Some aspects of reproduction of captive Canada geese. J. Wildl. Mgt. 32(4):894-905.

Presents basic information about the behavior, nesting density, and productivity of 110 pairs of captive Branta canadensis maxima. Management suggestions are presented. Findings: geese bred readily; overcrowding was the major cause of desertion or loss of nests; a water surface is required for courtship and copulation; preferred nesting sites border on the water.

Williams, C. S. 1967. Honker, a discussion of the habits and needs of the largest of our Canada geese. D. Van Nostrand, Inc., 179 pp.

The author states, "This book. . . has been written with the public, more than wildlife technicians and administrators, in mind." It is a readable account of Canada goose biology and behavior. The appendices provide good factual reference on classification, local names, breeding, distribution, migration, predation, parasites, feeding habitat, and mortality.

Yeagley, H. L. 1953. Some surprises in research. Audubon Mag. 55(4):158-161. July-Aug. 1953.

A physicist, primarily concerned with bird navigation, tells informative anecdotes of conditioning his experimental young mallards and wood ducks. After an initial fatal fiasco in pen-rearing wild wood ducks, author finds that simulating duckling's fall from tree nest triggers normal foraging behavior and stimulates duckling survival. Day-olds are tossed into water tub whose surface is covered with grass clippings. After splashdown, birds dip, bathe, and then start foraging. Without splashdown they appear deranged, frantic, and refuse to eat.

SECTION G

PESTICIDES, WEEDICIDES, AND MOSQUITO ABATEMENT

The 32 citations in Section G are only a minute fraction of the torrent of information that is literally swamping this field. Consider for a moment that one obscure specialists' journal, "The Mosquito News," has been published for thirty years and now attains about 400 pages annually. The abstracts in Section G were culled to provide a balanced base of the most significant papers on these subjects.

Anderson, D. M. 1966. Ecological factors affecting mosquito control on Utah marshes. Ph.D. Thesis, Univ. Utah, Diss., Abstr. 27(4):1320-B.

Ecological factors affecting mosquitoes are water, water management, soil, climate, vegetation, and wildlife propagation and management. A five-year study (1961 through 1965) by state and federal agencies, private organizations, and individuals made extensive analyses and evaluations of these factors for marsh shores of Great Salt Lake. Findings: All water management techniques employed were successful under certain conditions in reducing mosquito production. Often these techniques and controls improved the marshes for waterfowl and other wildlife. General recommendations for water management include confinement of water through adequate diking and/or alteration of topography and providing adequate water control structures for a flexible water management program. . . etc., etc. The paper generally lacks specificity.

Ashton, F. M. et al. 1963. Weed control recommendations. Univ. Calif. Agr. Ext. Svc. Publ. AXT-17, 28 pp.

The booklet contains two sections. In the first, a tabulated listing of selective weed control recommendations is presented. Each entry cites the crop, herbicide, rate/acre of active ingredient, spray-volume/acre, preferred application time, weeds that are controlled, and general remarks. In the second section, non-selective weed controls recommended for non-crop lands are tabulated. Listed are: name of the weed, recommended herbicides, application rates, spray volume and remarks on time, methods, etc. Many of the "weeds" listed are important upland and wetland plants. This publication is a useful quick reference for wildlife managers. An appendix lists 30 publications on weed control chemicals and equipment that can be obtained from the University of California Agricultural Extension Service.

Bauman, A. C. 1947. The effects of ammonium sulfamate on emergent aquatic vegetation. Trans. 12th N. Am. Wildl. Conf.:346-355.

Eight species of emergent and floating vegetation were treated with 1 lb. of Ammate® (80% ammonium sulfamate and 20% inert material) to 1 gal. of water; only black willow (Salix nigra) and water primrose (Jussiaea diffusa) were killed. When a detergent wetting agent, Vatsol OS, was used, two additional species--cattail (Typha latifolia) and water lotus (Nelumbo lutea)--were also killed. The spray seems non-toxic to livestock.

Beadle, L. D. and F. C. Harmston. 1958. Mosquitos in sewage stabilization ponds in the Dakotas. Mosquito News 18(4): 293-296.

Twenty-five counties in South Dakota and North Dakota were surveyed to determine the importance of sewage ponds as a mosquito source. Of 26 ponds inspected, 8 had no larvae; larvae of Culex tarsalis were found in 18. In all ponds where mosquitos were found, so was marsh vegetation. Conclusion: stabilization ponds with vegetation had a high C. tarsalis production potential and vice versa.

Bourn, W. S. and C. Cottam. 1950. Some biological effects of ditching tidewater marshes. USF&WS. Research Report 19, 33 pp., 6 maps.

This report, an out-of-print classic, is best summed up by the author's abstract: "Studies conducted over a 12-year period, 1935-47, of the biological effects of ditching tidewater marshes in Delaware for mosquito control, showed that marked ecological changes in the floral cover and invertebrate fauna followed such operations. These studies revealed that systematic ditching, which has proved useless as a mosquito control measure, resulted in shrubby growths succeeding the marshes' natural vegetation and greatly reduced invertebrate populations so important as waterfowl food."

Chapman, H. C. and F. Ferrigno. 1956. A three-year study of mosquito breeding in natural and impounded saltmarsh areas in New Jersey. Proc. 43rd Ann. Meeting, N. J. Mosquito Extermination Assoc.:48-64.

Best management plan to reduce Aedes and to increase food production for waterfowl (near Tuckahoe, N. J.) is late drawdown--July or August--followed by flooding as soon as millet growth is adequate.

Crafts, A. S. 1949. Control of aquatic and ditchbank weeds. Univ. Calif. Agr. Ext. Svc. Circ. 158, 16 pp.

The chemical controls cited in this 20-year-old circular have been generally superseded by other herbicides; the physical and mechanical controls are, unfortunately, not much changed in two decades. Discussed are: dredging, drying, hand-cleaning, burning, chaining, pasturing, mowing, and disking. Four common aquatic weeds (coontail, anacharis, sago pondweed, and muskgrass) are illustrated and discussed.

Crafts, A. S. 1955. Weed control by soil sterilization. Univ. Calif. Agr. Ext. Svc. Circ. 446, 20 pp.

Soil sterilization by chemicals makes the soil temporarily or permanently unfit for plant growth. Although this pamphlet does not include any mention of wildlife habitat, a field manager may find an occasional use for sterilants. This pamphlet lists the major chemical sterilants in use in 1955 and tells where and how to use them. Among chemicals discussed are borates, chlorates, bromides, disulfides, and arsenicals. Safer, more effective sterilants are in current use.

Eicher, G. 1947. Aniline dye in aquatic weed control. J. Wildl. Mgt. 11(3):193-197.

Aniline dye was tried on Arizona lakes in an attempt to inhibit emergent plants by excluding light. Of the dyestuffs tested, Nigrosine (black dye) was cheapest and most permanent. Dye applied at a rate of 10 lbs. per surface acre did not entirely inhibit plants. Fifteen lbs./A. of Nigrosine was applied to another lake. The effect was noted the following year, when normally semi-emergent weeds failed to reach the surface. Changes in the water chemistry of the lakes were noted; pH, which heretofore advanced seasonally, failed to do so. Although the method gave some control, it was adjudged too costly for general application.

Frank, R. A., N. E. Otto, and T. R. Bartley. 1961. Techniques for evaluating aquatic weed herbicides. Weeds 9(4):515-521.

Both standing-water and limited contact tests were used. Standing-water tests consisted of placing representative species of submersed aquatic weeds in 20-liter glass containers with various solutions of herbicides. Limited contact consisted of a 30-minute exposure in flowing water, then the plant was placed in fresh water. Seven compounds were effective in standing water at 100 ppm. and four were effective in limited contact at 600 ppm.

Gerking, S. D. 1948. Destruction of submerged aquatic plants by 2,4-D. J. Wildl. Mgt. 12(3):221-227.

Anacharis canadensis, Anacharis densa, Vallisneria spiralis, and Myriophyllum sp. were killed by a concentration of 100 ppm and definitely inhibited by 10 ppm. The alga Cladophora was unaffected by 100 ppm of 2,4-D.

Grigsby, B. H., C. A. Heimer, and W. A. Cutler. 1955. Observations on the control of cattail, Typha spp., by chemical sprays. Mich. State Coll. Quart. Bull. 37(3):400-406.

Results of one-year and two-year tests of Dalapon and other herbicides in southern Michigan ditches: 1. Seasonal control of cattails was obtained from 6.8 - 13.6 lbs. of Dalapon per 100 gallons of water. 2. Adding one pound of Silvex (2,4,5,-T) increased kill in all Dalapon rates. 3. Regrowth after treatment was least where growth inhibitors had been applied along with Dalapon. 4. Recommended rate in cattail-blocked drain ditches: 13.6 lbs. Dalapon per 100 gallons (Silvex optional).

Haeger, J. S. 1960. Behavior preceding migration in the salt marsh mosquito, Aedes taeniorhynchus (Weidemann). Mosquito News 20(2):136-147.

Pre-exodus behavior of species was observed. If flowers are present, the mosquitoes may feed on nectar before departure; as a result, if males are old enough, matings may occur during the exodus. Milling over the emergence site was noted. Presumably milling preceded migration. For the first time, directional flight of migrants was observed. Aedes flew upwind at low wind velocities, but fell downwind at high velocities. The insects were also seen, on a calm day, flying into the sunset.

Hanson, W. R. 1952. Effects of some herbicides and insecticides on biota of North Dakota marshes. J. Wildl. Mgt. 16(3):299-308.

Two herbicides--2,4-D amine and water, and 2,4-D ester and oil--reacted similarly on dicotyledons and produced a heavy kill. Monocotyledons were affected more severely by 2,4-D ester and oil. Chlordane with water interfered with bird reproduction by reducing nesting success and killing juveniles. Toxaphene proved to be harmful to all animal life except birds and some small crustaceans. DDT was the most effective insecticide; after spraying there were no live insects on the area and birds were forced to feed elsewhere or to eat the dead insects. Proper tillage and crop rotation, rather than chemical sprays, are recommended by the author.

Harmic, J. L. 1960. Impoundments for mosquito control and wildlife in Delaware. Proc. N. E. Sec. Wildl. Soc. Ann. Conf., 4 pp. Mimeo.

Three-year study (1956-58) shows mosquito production is reduced and wildlife use increased by impounding marshes,

particularly if water level is kept stable. The author states that this is a far better method than draining, ditching, or spraying.

Heath, R. G. and L. C. Ruch. 1957. Aerial control of cattail with Radapon. Down to Earth. Dow Chem. Co., Midland, Mich. 13(3):14-16, 2 photos.

Cattail growing in less than 8" of water were 90% controlled one year after aerial spraying with 10 lbs. of Radapon. Ten pounds gave the same amount of control as twenty pounds. Four gallons of aqueous solution per acre gave adequate coverage. Cattail standing in water deeper than 8" and treated as above (10 lbs.) were only 65% controlled. Dalapon reportedly caused no significant damage to the valuable waterfowl foods present.

MacNamara, L. G. 1952. Needs for additional research on mosquito control from the standpoint of fish and game management. Proc. 39th Ann. Mtg. N. J. Mosquito Extermination Assoc.:111-116.

Natural salt marshes producing ducks, rails, and muskrats lose much of their value when ditched and drained for mosquito control. Impoundments, drawn down during summer, are an alternative to ditching. Annual duck foods grow and few mosquitoes are produced. Another solution is ponding pools in mosquito marshes. The paper recommends water level controls and wise use of pesticides.

MacNamara, L. G. 1953. The production and preservation of wildlife in relationship to mosquito control on state owned lands in New Jersey. Proc. 40th Ann. Mtg. N. J. Mosquito Extermination Assoc.:74-77.

Discusses impoundments subject to summer drawdown and their value to wildlife and mosquito control. Mosquitoes are not uniformly produced in marsh; ponds or artificial potholes with good fish population may solve the problem. The thesis advanced is: When a public agency takes over an area for wildlife, the agency's responsibility is to see that control of mosquitoes is at least as efficient as prior to take-over.

Martin, A. C., R. C. Erickson, and J. H. Steenis. 1957. Improving duck marshes by weed control. USF&WS Circ. 19, rev., 60 pp.

First printed in 1953, revised in 1957, this booklet deals mainly with the chemical control of a score of wetland

plants. Physical controls are described for a few species and biological controls are mentioned. A useful and practical resume that must be employed with some caution by present-day marsh management.

Meyer, F. A. 1964. Aquatic plant control. Calif. Dept. F. & G. Inland Fisheries Admin. Report No. 64-2, 31 pp. Mimeo.

This report discusses biological and mechanical controls briefly, chemical controls in detail. The more common aquatic plants, their problems and control methods, are summarized. The chemicals in current (1964) use are described: copper sulfate, dichlone, RADA, monuron, monuron TCA, sodium TCA, diuron, fenuron, neburon, arsenic trioxide, endothal, simazine, diquat, aromatic solvents, chlorinated benzine, acrolein, atrazine, casoron, fenac, paraquat, erbon, 2,4,5-T, silvex, 2,4-D, amitrole, and dalapon. Surfactants are also described. Application suggestions, application rate tables, and a list of chemical suppliers are included.

Provost, M. W. 1959. Impounding salt marshes for mosquito control--and its effect on bird life. Fla. Nat. 32(4):163-170.

Impoundment has resulted in increased bird life and better bird habitat.

Rees, D. M. and D. M. Anderson. 1966. Results of multipurpose water management studies on marshes adjacent to the Great Salt Lake, Utah. Mosquito News 26(2):160-168.

With effective, rapid water control and management the marshland was improved for wildlife and mosquitoes were abated. Stabilizing water depth at 12" virtually eliminated all mosquitoes and provided good waterfowl habitat. Seasonal drawdown gave effective mosquito control. Flood-irrigation, if properly controlled, did not produce mosquitoes. Marsh should be diked into units that can be manipulated quickly for water control. As a guide in planning the authors state, "The Utah State Department of Fish and Game calculates that each cfs flow of water entering a marsh can irrigate or flood one hundred acres of marsh ground."

Rose, E. T. 1954. Blue-green algae control at Storm Lake. Proc. Iowa Acad. Sci. 61:604-614.

After severe toxic concentration of Cyanophyta in 1952, and high waterfowl mortality, this lake was sprayed with

copper sulfate at a rate of 13.3 lbs. per surface acre. Results were good and the treatment apparently had no serious adverse effects on fish or fish foods.

Rudd, R. L. 1964. Pesticides and the living landscape. Univ. Wisc. Press, 320 pp.

A broad treatment of a complex subject. Chapter 2, "An Introduction to Chemical Pesticides"; Chapter 6, "The Invertebrates--Water, Soil, Surface"; and Chapter 7, "The Cold-blooded Vertebrates" are useful reference for wetlands students.

Rudd, R. L. and R. E. Genelly. 1956. Pesticides; their use and toxicity in relation to wildlife. Calif. Dept. F. & G. Game Bull. No. 7, 209 pp.

This 13-year-old treatise was the first definitive work on a problem that has proliferated overwhelmingly. This study is still one of the most complete and succinct in its field. Every concerned wildlife biologist should read this work, particularly pages 28-40. Since nearly 90 pesticides are reviewed, the bulletin is also a comprehensive reference.

Snow, J. R. 1956. Algae control in warmwater hatchery ponds. Proc. 10th Ann. Conf. S. E. Assoc. G. & F. Comm.:80-85.

In hatchery ponds, where copper sulfate or sodium arsenite has given poor control of algae, Delrad (Abietylamine acetate) has been used satisfactorily. Advantages and disadvantages of each algacide are discussed.

Springer, P. F. 1964. Wildlife management concepts compatible with mosquito suppression. Mosquito News 24(1):50-55.

A solid article that discusses physical and biological principles and compatible controls. Dr. Springer's summary: "Application of physical and biological principles offers the most acceptable means of developing compatible programs for wildlife management and mosquito control. When chemical control is used, it should supplement rather than work against physical and biological methods. Programs coordinated in this manner are in the broad public interest."

Steenis, J. H. 1950. Studies on the use of herbicides for improving waterfowl habitat in western Kentucky and Tennessee. J. Wildl. Mgt. 14(2):163-169.

Ammate (ammonium sulfate) at 3/4 lb./gal. of water and 2,4-D at 6% strength effectively controlled lotus and giant cutgrass. For best results Ammate must be used after flowering, but 2,4-D should be used during flowering time. 2,4-D was most effective during active vegetative growth. Alternate treatments with Ammate and 2,4-D on hard-to-kill woody species and spatterdock proved more effective than double treatment with only one compound.

Timmons, F. L., L. W. Weldon, and W. O. Lee. 1958. A study of factors which influence effectiveness of Amitrol and Delapon on common cattail. Weeds 6(4):406-412.

Late season treatment on mature cattail proved more effective than early season treatment; 20 lbs./A. in split applications were more effective than 10 lbs./A. and as effective as 40 lbs./A. Dalapon's effectiveness increased with the addition of diesel oil and emulsifier. Amitrol's effectiveness did not increase with additives.

Tindall, E. 1961. A two year study of mosquito breeding and wildlife usage in the Little Creek impounded salt marsh, Little Creek Wildlife Area, Delaware, 1959-60. Proc. 48th Ann. Meeting N. J. Mosquito Extermination Assoc.: 100-105.

Impounding eliminated Aedes sollicitans and water level management reduced Culex, Anopheles, and Unanotaenia. Increase in wildlife species was noted after impounding.

Weir, J. L. and D. F. Starr. 1950. The use of rotenone to remove rough fish for the purpose of improving migratory waterfowl refuge areas. J. Wildl. Mgt. 14(2):203-205.

A 250-acre lake was poisoned by rotenone flown in by helicopter. This marshy lake was thoroughly saturated. Fifteen tons of fish, mostly carp, were killed. The dead fish were preyed on by gulls who suffered no ill effects from rotenone. Lake waters cleared promptly and waterfowl were no longer harassed by fish.

Whitesell, K. G. 1965. Large scale granular Parathion pre-treatment of a duck club area in the Colusa (California) Mosquito Abatement District, Utah Mos. Abatement Assoc. Conf., Brigham Young Univ., March 26-27, 1965, 2 pp.

In the famous waterfowling marshes of Butte Sink in California, customary abatement measures are ineffective and costly. Aircraft spreading 2 lb. per acre of 5% Parathion volclay granules over a 50 ft. swathe gave a dosage of 0.1 lb./A. of actual toxicant. Total application was 16,800 lbs. of Parathion granules to 8,140 acres. September and October mosquito counts were less than 10% of previous year. No deleterious effects were noted for game or fish. Since midsummer water fluctuation, an essential management practice, is precluded in many water areas because of mosquito abatement regulations, this insect control technique of treatment prior to flooding marshlands may be extremely useful.

SECTION H

LAGNIAPPE

The Louisiana Creole calls it "lannyap"--meaning just a little something extra. These 16 entries in Section H are not only hard to fit into a category; they are a little too special to be swamped by the mass of the other papers.

Cartwright, B. W. 1949. Restoration of waterfowl habitat in western Canada. Trans. 5th N. Am. Wildl. Conf.:377-382.

Of historical interest. Describes early work carried out by Ducks Unlimited on ruined marshlands of southwestern Alberta and in Manitoba.

Coe, M. D. 1964. The chinampas of Mexico. Sci. Am. 211(1): 90-98.

Chinampas are long, narrow strips of land surrounded on at least three sides by water. They have produced excellent crops along the shores of Lake Xochimilco and Lake Chalco in the valley of Mexico, and have remained consistently fertile for over 2,000 years. The system is now critically endangered by modern progressive urbanization. The techniques of chinampa farming for maize, fruit, flowers, fish, and axolotls are discussed.

Davison, V. E. 1947. Water weeds for sale. J. Wildl. Mgt. 11(1):95-96.

The author blasts commercial plant nurseries for indiscriminately peddling often-noxious weeds as good fish food plants or high value duck forage. He deplores the failure of the uninformed private landowners to seek professional advice before introducing exotics into their ponds and marshes. The author's complaint was valid then; twenty-two years later, it still is.

Dickey, C. 1960. Shooting preserve management. Sportsmen's Svc. Bur., New York, 94 pp.

Commercial shooting preserves are often a logical recreation development for managed wetlands and this is the best single publication on the private preserve. Includes suggestions on food and cover development, preserve dogs, upland game bird management, flighted mallards, public relations, advertising, etc.

Dye, W. B. and J. L. O'Hara. 1959. Molybdenosis, Univ. Nevada Agr. Expt. Sta. Bull. 208, 32 pp.

Molybdenosis is a toxic condition of cattle, resulting from their ingestion of forage rich in the trace element, Molybdenum. Such forage is customarily found growing in alkaline basins or sinks where drainage is poor and water table high. Legumes usually collect more Mo than do grasses. Cattle suffering from Molybdenum toxicity usually scour, lose weight, have rough hair, unnatural

appetite, low sex drive, and suffer from phosphorus deficiency that causes weak and brittle bones. Copper glycinate injections have been found to be the specific cure for this disease. (N.B. Molybdenosis may occur on alkali wetlands where waterfowl production is integrated with grazing. See Section D: Arend, 1963. P.H.A.).

Mathes, G. H. Quicksand, Sci. Am. 188(6):97-102.

A semi-popular article tells how quicksands and alkali bogs are formed; where such natural traps can be expected; how danger can be avoided or overcome; how to handle livestock in these perilous wetlands.

Norman, M. 1949. The good old days of waterfowling. Outdoor Life 103(4):36-39, 83-85. April 1949.

Included just for fun--and to teach perspective: this is what it's all about--the history of waterfowling in the U. S., from the early days until the 1930's. Tells of sink boxes, bushwhack boats, toll dogs, and blames waterfowling decline on market-hunting greed.

Poll, C. M. 1967. Water from afar--North American Water and Power Alliance (NAWAPA). Proc. 47th Ann. Conf. W. Assoc. F. & G. Comm.:135-145.

This citation has little to do with western wetlands management per se but the scheme, if borne out, would have such a far-reaching impact that any wetlands manager should know of the plan's existence. In brief, NAWAPA would collect unused water from Alaska and Canada and deliver it to water-scarce regions of Canada, U. S. and Mexico. Although the plan (to deliver 80,000,000 AF to U. S., to put 25,000,000 acres under crops, to create 51 interconnected lakes and reservoirs, to support an added 137,600,000 inhabitants, etc., etc.) sounds like an hallucination, it really only takes about twenty times as much water as the existing California Water Plan will develop for California alone. NAWAPA could happen!

Project MAR. 1962. The conservation and management of temperate marshes, bogs, and other wetlands. (IUCN) Intern. Union for Conservation of Nature and Nat. Res. Publ. No. 3.

The proceedings of a blue-ribbon international conference in 1962, in Europe. The following articles are recommended for study: Chapter 3, E. B. Odum explains gross primary productivity of tidal marshes. Chapter 5, H. H. Buisman,

reports from Holland that the Dutch government is ceasing to subsidize reclamation but will try to retain their few thousand remaining acres of wetlands. The Netherlands is deviled by crop surpluses in dairy products; "waste" or reed-lands give more profit per acre from thatching and shielding products than agricultural land returns. Other papers: English use gravel pits for waterfowl development; Germans have developed sewage outfall ponds for commercial fish production and for waterbird use; Ranswell (England) discusses wetland invertebrates; Jansen (U. S.) summarized USF&WS marsh management; etc., etc. Some of the papers resemble an Arizona thunderstorm--lots of wind, not much water.

Project MAR. 1965. The conservation and management of temperate marshes, bogs, and other wetlands. Morges, Switzerland, (IUCN) International Union for Conservation of Nature and Natural Resources, Vol. 1 #5 (New Series)

Multilingual publication, with data derived from an earlier international conference, presents a fairly detailed listing of wetlands acreages and locations in Europe, the Mediterranean coastal areas, and parts of the Middle East. European USSR is included, but Asian USSR is not listed. This is probably as good a general current reference as is available.

Robert, G. L. 1964. Relationships of certain climatological factors to the autumn migration of waterfowl in the Central Flyway. Ph.D. Thesis, Okla. State Univ., Diss. Abstr. 26(3):1838.

Study reviews major literature correlating migration and weather. Waterfowl migration and weather data of 1953-55 were computerized. Conclusions: Waterfowl migration varied from year to year, due to variation in weather and water conditions. Falling temperatures produced more major movements than any other weather phenomena. A strong cold front moved the dabblers, but not always the geese and divers. Cloud cover presaged departure, as did upper air tailwinds and crosswinds. Snowfall, headwinds, and variable winds prevailed during periods of no migration. Barometric pressure change, direction of surface wind, and rain were apparently unrelated to waterfowl migration.

Salyer, J. C. 1936. Practical waterfowl management. Trans. 1st N. Am. Wildl. Conf.:584-598.

Of historical interest, this article contains problems and projections for U. S. Refuge program, then in its infancy.

Scheffer, P. M. 1958. Farming for waterfowl. Trans. 24th N. Am. Wildl. Conf.:238-244.

Reports on the assistance given in waterfowl marsh management by the U. S. Soil Conservation Service to 65 individual farmers and 12 duck clubs during 1957 and 1958, using common farming and irrigating techniques. Non-agricultural desert lands or poor quality farmlands produce feed and cover for waterfowl. Watergrass, sudangrass, field corn are planted, and then flooded during duck season. Initial development costs per acre and annual maintenance costs (as of 1958) are listed. Cost-sharing and other agency features are briefly discussed.

Schoenfeld, C. 1949. Good-by pot-holes. Field and Stream 53(12):35-37, 150-153. April 1949.

Written during the controversy over the SCS pothole drainage program of the 1940's and 1950's, this article states that pothole drainage is destroying most waterfowl habitat in North and South Dakota. Contains valuable inventory material and provides historical insight.

Wolfe, C. 1967. Duck hunting in Arizona. Ariz. Wildl. Sportsman 39(11):14-15.

Popular-type picture story inadvertently points up paucity of good wetlands management in Arizona. Good marsh plants have been replaced by saltcedar, the author states. The few remaining watercourses are listed: the Salt, Gila, Verde, and Colorado Rivers; mentioned are the natural and man-made lakes of the Colorado Plateau and Mogollon Rim.

Yocom, C. F. 1950. Weather and its effect on hatching waterfowl in eastern Washington. Trans. 15th N. Am. Wild. Conf.:309-317.

Writer finds that a cold, wet spring holds back nesting and that peak of hatch may be delayed by two weeks. Suggests flooding, temperature, and/or decreased light, or interaction of all three as causative factors.